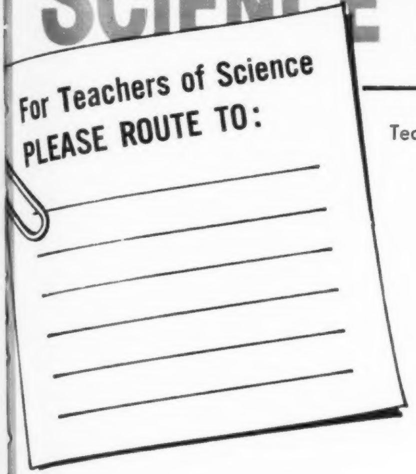
SCIENCE TEACHER'S WORLD

Teacher's edition of **SCIENCE WORLD** May 4, 1960



Using *Science World* in Your Teaching

Laboratory Under Your Feet (pp. 5-8)

Biology Topics: Plant nutrition; synthesis of compounds by plants; carbon, nitrogen, and sulfur cycles; transport through roots; formation of soil.

Chemistry Topics: Ionization, hydrogen ion concentration, ion exchange, biochemistry.

Earth Science: Soil formation, composition, physical and chemical properties, economic importance.

About This Article

What is so common as soil, yet so little understood? What so precious, yet so little appreciated? What so essential, yet so wantonly wasted? Surely, it is the responsibility of science in the curriculum to develop in the citizens of tomorrow an adequate understanding and appreciation of soil—and of its relation to life, particularly to *human* life.

To develop an adequate comprehension of the complex, dynamic medium in which the land plants of the world are rooted, takes the combined disciplines of earth science, physics, chemistry, and biology. This article dips into *all* these disciplines. It describes the reduction of rock to colloidal particles, how organic compounds come to be mixed with these particles, and the manner in which all these are associated with the roots of plants in a veritable three-dimensional, two-way stream of ions moving under the influence of electrical forces. The article stresses the importance of physical consistency as a factor in soil efficiency, and describes some experimental work with recently developed synthetic soil-conditioners.

Naturally, the story includes the carbon, nitrogen, and other chemical "cycles" in nature, and the part that microorganisms play in these cycles. Altogether, this article is rich fare for the student in your science class whatever the branch of science you are teaching.

Topics for Special Reports

1. How is the Earth's crust continually being broken down into rocks, gravel, sand, clay?
2. How do lichens manage to live on bare rocks?
3. Explain the following succession of life on a rock: lichen followed by mosses, followed by ferns, followed by seed plants.
4. How does lightning help dissolve rocks?
5. What microorganisms are involved in the nitrogen cycle?
6. What is *ion exchange?* How does it take place between soil and plants?
7. How does hydrogen-ion concentration in soil change naturally? How may it be changed artificially?
8. Compare natural with artificial soil conditioners, giving the advantages and disadvantages of each.
9. Describe and discuss von Liebig's "balance sheet" theory of plant nutrition.
10. Explain this statement: "Soil is more than a substance, it is a *process.*"

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Nitrogen Fixing Bacteria

Nitrogen fixing bacteria are rather easily observed with either the medium or high power of the microscope. Have students collect the entire root system or a sample of the roots from one or more of the following plants: red clover, white clover, soybeans, vetch or black locust (shallow roots). Wash the roots well. Note distribution and number of nodules on various plants and species. Are there differences?

Select a large nodule, cut it open, and smear the cut surface on a clean glass slide. Add a drop of water and observe as a wet mount. Smears may be fixed with heat and stained with methylene blue. Bacteria are rods: straight, club shaped, or Y shaped.

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Case of the Foolish Seedlings (pp. 9-11)

Biology Topics: Plant hormones, plant growth substances, conditions of germination, vegetation propagation, interrelationships among living things

Chemistry Topic: Organic chemistry

About This Article

No science fair, these days, is complete without its share of tesla coils, cloud chambers, and—more recently—photographs of plants that have been given the gibberellin treatment. The latter are bound to appear increasingly in coming science fairs, for the gibberellins, like the tesla coil and cloud chamber before them, are now in vogue. What Mr. Bleifeld does is to raise student-activity with gibberellins from the display-of-an-oddity stage to an experience-in-research stage. For an eager student, his article provides a historical-and-content background, an invitation to research, and adequate details for getting started. Altogether, it is

made-to-order—so to speak—for the teacher who wants to cultivate the young scientists in his class. Biology teachers will be grateful to Mr. Bleifeld for this skillfully designed and well written educational "auxin."

Teaching Suggestions

There are several places in the traditional biology course of study where the gibberellins could be included. For example, when studying microorganisms, gibberellic acid and penicillin could both be considered as products of molds, but as having opposite effects. It might be interesting to speculate on the role that these substances play in the survival of the organisms that produce them. In the study of seed germination and of plant growth, the gibberellin story would certainly be appropriate. The subject of this article might be brought even into the study of genetics. For example, can the tallness of a tall breed of pea plants be explained in terms of a gibberellin-like substance being released by a gene?

Here is a suggestion for using Mr. Bleifeld's article to stimulate a group project in your biology class. Have the class read the article. Call attention to the kinds of investigations the article suggests. Elicit from the class some possible investigations: effect on germination of radish seeds, effect on growth of potatoes, and the like (students may show surprising ingenuity in experiments they suggest). Appoint a committee to make up stock solutions of graded concentration. Appoint a monitor who will dispense solutions to "investigators" as needed. Investigators can then set up their experiments in school or at home. When ready, they could be scheduled to report their observations to the class.

The Tiniest Magnets (pp. 12-15)

Chemistry Topics: Paramagnetic substances, ferromagnetic substances, ferrites

Physics Topics: Theory of magnetism, atomic structure, the tape recorder

About This Article

Try bringing together opposite poles of a couple of powerful alnico magnets and you "feel" an invisible and quite mysterious "fluid" along which the magnets seem to slide. Few experiences excite greater wonder. Mr. Dresner presents some current theories regarding magnetism—theories to account for some observed magnetic phenomena and to explain some of the recently developed uses of magnetic substances.

Magnetism is traced to an imbalance of spinning electrons within atoms. Micromagnets within a substance may be aligned or disarranged. When they are aligned, magnetism is evident; when they are disarranged, magnetism seems to disappear. A distinction is made between paramagnetic and ferromagnetic substances, and the differences are explained in terms of aggregates called *domains*. The nature of these domains determines the "power" of a magnetic material.

Considerations such as these have led to the manufacture of ferrites by mixing and compressing oxides of nickel, zinc, iron, manganese, and other metals. The development of ferrites made possible magnetic tape, now used in sound and video recording and in electronic computers. No doubt, wonderful new uses for magnetic materials will continue to be found.

Demonstrations

1. To mystify your class, tie a paper clip to a string and suspend it upward, defying the force of gravity (under the influence of a magnet over it, and hidden in a paper box).

2. Suspend an iron nail from a string so that it leans toward (but does not touch) an adjacent magnet. Heat the nail with a torch. The nail loses its induced magnetism and swings away. As it cools, it regains its magnetism and resumes its leaning position. (Credit: Dr. Baxter, Continental Classroom.)

Review Questions

1. Define each of the following: (a) Bohr magniton; (b) paramagnetic substance; (c) Curie point; (d) ferromagnetic substance; (e) domain; (f) ferrite; (g) ferrite magnet.

2. Explain what happens inside a piece of iron: (a) when it is magnetized (b) when it is demagnetized.

3. How may heat demagnetize a magnet?

4. What substances are used in the manufacture of ferrites? How are ferrites made?

5. Of what is magnetic tape made? How does it record? How does it play back?

6. In what devices is magnetic recording tape used?

Mister Isotope (p. 20)

Physics Topic: Radioactivity

Chemistry Topic: Isotopes

Biology Topic: Circulation of blood

About This Article

This is a short biography of Dr. Paul C. Aebersold, Director of the Office of Isotope Development of the U.S. Atomic Energy Commission. His interest in science is traced from the time he built his first crystal-radio set, as a 12-year-old boy, through the time when, as a young physicist, he assisted with the building of a 26-inch, a 60-inch, and a 184-inch cyclotron, to the present, when he is directing an educational program involving the products of atomic piles and cyclotrons. The products are isotopes for use in industry, medicine, and research. It will not go unnoticed by young readers that the scientist-hero of the story was a star athlete when he began his research at Berkeley.

On the content side, the article lucidly reviews the nature of isotopes and some of their uses. In particular, the use of radioactive sodium in studying circulation of blood is described in detail.

Some Review Questions

1. What is an isotope?

2. What is the derivation of the word "isotope"?

3. How does a stable isotope differ from a radioactive isotope?

4. What is the atomic structure of protium? deuterium? tritium?

5. What advantage has the cyclotron over the atomic reactor in the production of isotopes?

6. What advantage has the atomic reactor over the cyclotron in the production of isotopes?

7. To what extent are isotopes being used today in medicine, industry, and in scientific research?

Tomorrow's Scientists (pp. 21-24)

Test Atmospheres on Plants

John Murdock's report may be held up to the class as an example of a project that requires a minimum of special equipment. Moreover, the method John used is applicable to a wide variety of investigations. Therefore, it may suggest projects that other students may undertake. For example, here are a few problems that can be investigated:

1. *Lemna minor* is a small floating plant that divides vegetatively and separates quickly. How rapidly does this plant divide under various amounts of light, of heat, of water acidity?

2. By placing a culture or an organism on a floating pan, an earthworm, a mold, a small insect, or a small crustacean could be subjected to various "atmospheres." What would be the effects on them?

3. Can a mat of floating duckweed produce sufficient oxygen, through photosynthesis, to sustain a small invertebrate animal?

Students may think of other problems for investigation, keeping in mind the possibility of life in the atmosphere of other planets.

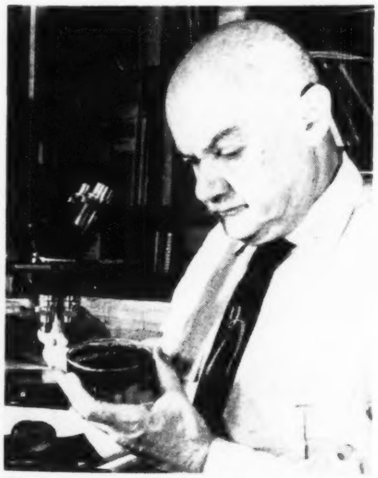
Ten new films range the spectrum of the sciences to stimulate the imagination of students

HORIZONS OF SCIENCE FILM SERIES

***Project Mohole*—Core sample, representing 9 million years of sedimentation, is removed from a depth of more than 3 miles by scientists of *Vema*.**

HORIZONS of Science, in association with the Educational Testing Service of Princeton, New Jersey, has completed production of a series of ten science films. The ten color films, each about 20 minutes in length, cover the broad spectrum of the sciences. The physical sciences, life sciences, behavioral sciences, and mathematics are all represented.

The films are not teaching films in the ordinary sense but imagination stimulators and wonder builders. They were designed for the multifold purpose of arousing interest, broadening understanding, and creating a favorable image of the scientist at work. Thus the primary emphasis of each film is on the intellectual adventure of the scientist as he pushes the frontier of knowledge forward. But real adventure of the type exciting to students also receives full measure.



***Worlds of Dr. Vishniac*—Life function of microscopic, one-celled animals is revealed through unusual cinemicroscopy.**

In the film "Project Mohole" the student viewers will be transported from the classroom to the deck of the oceanographic research ship *Vema* of the Lamont Geological Observatory. Aboard the *Vema* they will observe scientists searching for earth's most tender and thin-skinned spot, in which to sink the Moho probe. The change of pace from the decks of the *Vema* to the top of Palomar to visit with Dr. Allan Sandage, will give young viewers a glimpse of the professional astronomer at work. For the first time, most students will realize that astronomical telescopes are not for "looking through" but for taking pictures. In contrast to the popular image of the astronomer as a squinting cosmic pedant, young people will see the astronomer as a thoroughly normal person, who like most of us would rather avoid tedious hours of painstaking adjustment. The real and exciting explorations of the cosmos are not made at the telescope, but by painstaking instrumental and statistical analysis of photographs produced by these giant "cameras."

But as the observatory's giant dome swings open to expose the 200-inch mirror to the twilight sky above Palomar, students will feel a sense of wonder and delight, both at the nature of the universe and the exquisite precision of man and his tools as he probes the heavens for the meaning of events that occurred millions or billions of years ago.

"The Realm of the Galaxies" might well be followed by the "Worlds of Dr. Vishniac," a beautiful film of a famous scientist gently and lovingly observing the microcosm of the protozoans. Here is an opportunity to point out the unity of science and the community of thought and discourse among scientists, whether their field of specialty is the stars of the heavens or the creatures of a roadside rain puddle. There is adventure and wonder everywhere.

One of the high points of the series occurs at the end of the Vishniac film. In the closing sequence Dr. Vishniac walks along the bank of a pool and turns back to the water a sample containing the protozoans he has used for study. He states the credo of a scientist with beautiful simplicity and clarity.

"I only borrowed them [the protozoa] for observation, for study, for photography. They are living beings and I am happy to return them to nature. . . . When I am returning the organisms to nature, I feel that I have the right to take again a little part of nature. And I feel I am a little part, a building stone of nature—and this is so wonderful, to belong to nature, to be just one part of the cosmos. . . .

"It is so important to be interested, to look around and to look closer. We'll see more. We'll achieve more. We will be wiser and the world will be bigger—the world around us."

Each film is accompanied by a discussion and study guide designed for teacher use. An unusual feature of the

guide is a synopsis of the film and a list of sequences. This important feature will be of great aid to the teacher who may not have an opportunity to preview the film. Reference to the sequence list will permit the teacher to get students "set" to observe portions of the film particularly pertinent to work in progress or concepts that have been developed earlier.

In addition to the synopsis and sequence list, the guide includes questions for discussion and analysis that enable the upper grade elementary teacher also to use the film series to maximum advantage. These features—together with test questions, student activities, and projects—provide a dimension to the film series that seems worth investigation.

Completion of the "Horizons of Science" program culminates work supported by an initial grant from the National Science Foundation. The films, made by professionals of wide experience, are technically excellent. No fault can be found with either sound or color. The over-all quality of the photography is good and occasionally superb, as in the case of Roman Vishniac's motion shots through the microscope.

Each film was supervised by a scientist well known in the field, acting as supervising consultant. Among them are many scientists whose names are widely known: Dr. Hadley Cantril of Princeton, Dr. Margaret Mead of the American Museum of Natural History and Columbia University, the late Dr. Donald J. Hughes of the Brookhaven National Laboratories, and Dr. John Nafe of the Lamont Geological Observatory.

The films are available for direct purchase by school systems. However, many sets have been purchased by leading corporations for free use in the schools. To find out the source of the series nearest you, write to the Educational Testing Service at 20 Nassau Street, Princeton, New Jersey, or 4640 Hollywood Boulevard, Los Angeles 27, California.

A brief description of each film follows.

Visual Perception—with Dr. Hadley Cantril of Princeton. Distortions which result from faulty assumptions are demonstrated with spectacular results by a prominent psychologist; the importance of sound assumptions to the success of scientific method is emphasized.

The Worlds of Dr. Vishniac—The life functions of microscopic, one-celled animals are revealed in all their complexity through extraordinary cinemicroscopy by Dr. Roman Vishniac, well-known microbiologist; satisfactions to be found in life sciences are highlighted.

Exploring the Edge of Space—Applications of plastic balloon technology to space reconnaissance at 100,000 feet are demonstrated by venturesome aeronautical engineer Otto C. Winzen of Minneapolis. The interdependence of scientific disciplines is shown.

"Thinking" Machines—with Claude Shannon of MIT, Alex Bernstein of IBM, and Leon Harmon of Bell Laboratories. Approaches and experiments in machine "intelligence" are shown. A mechanical mouse that learns by trial and error, a chess game against a giant computer, and a machine that recognizes visual patterns are highlights.

The Mathematician and the River—An illustrative problem in applied science, flood control on the Mississippi River, is used to show the relationship between the "abstract" world of mathematics and the "real" world of nature. With Eugene Isaacson of NYU's Institute of Mathematical Sciences.

New Lives for Old—with Dr. Margaret Mead of the American Museum of Natural History. Research in cultural anthropology. The story of striking change experienced in a 25-year period by the Manus people of the Admiralty Islands, and of the society's adaptation to a new way of life.

Project "Mohole" – In search of knowledge about the composition and history of the earth, a team of scientists is planning to drill a hole through its crust, through the Mohorovicic Discontinuity or "Moho," and on into the earth's mantle. This film report shows the first stages of the "Mohole" Project. Using oceanographic methods, geologists and geophysicists probe and survey the ocean floor to find where the "Moho" might be within reach. With Dr. John Nafe of the Lamont Geological Observatory.

The Realm of the Galaxies—An inquiry into the farthest reaches of the universe, with Dr. Allan R. Sandage of the Mt. Wilson and Palomar Observatories, California. Stimulation is provided by the awesome beauty of distant galaxies.

The Flow of Life—Basic research in the microcirculation of the blood and the capillary beds, with Dr. Benjamin Zweifach of the NYU College of Medicine and his associates.

Neutrons and the Heart of Matter—Exploring the nature of matter and the significance of the neutron's behavior, with the late Dr. Donald J. Hughes of Brookhaven National Laboratories.

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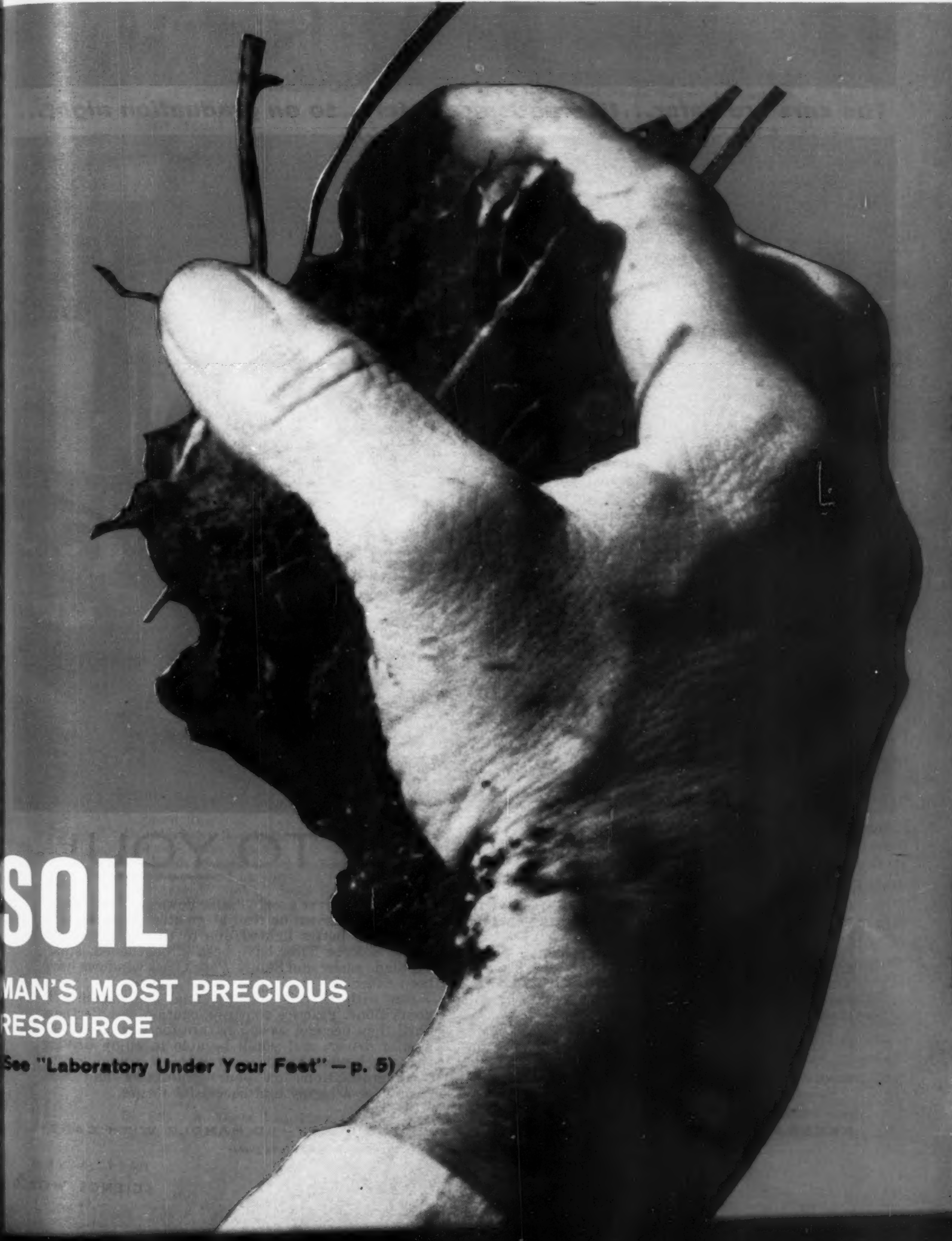

SOIL

MAN'S MOST PRECIOUS RESOURCE

(See "Laboratory Under Your Feet" — p. 5)

SCIENCE WORLD

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C O N T E N T S

Features

Departments

Cover photo from U. S. Department of Agriculture

Science in Quotes

In the darkness of a deep cave, a flashlight yields valuable clues about one's surrounding. . . . Scientific discovery is like the beam of a flashlight. It affords some vague indications as to the nature and meaning of the world.

But the tiny pencil of light from a flashlight also tends to make the darkness vivid. Stretching in every direction, there is no way to discover its extent. It would be utter foolishness to identify a tiny illuminated spot with one's total surroundings . . . cave and universe around us hold secrets that our feeble light cannot reveal. About the most that can be said of any successful seeker for scientific truth is that he has gained a partial understanding of some aspect of the problem.

—GARY WEBSTER
Wonders of Science

Letters

Goose Pimples

Dear Editor:

Many times when a person becomes chilled or cold [or frightened] little bumps called goose pimples appear on the skin. What causes them?

Roberta Fulton
White Lake, N.Y.

Answer. Goose pimples are caused by the same thing that causes a cat's hair to stand on end when it is cold or angry. Each hair is attached to a tiny muscle. Most mammals respond to cold by raising the fur with these tiny muscles. With human beings, who have so little hair that it doesn't make any difference, the contraction of the muscles attached to the hairs merely produces tiny bumps.

When we are frightened, the action of certain hormones in our bodies often causes the temperature of the skin to drop and we feel cold. Result—goose pimples.

Sounds From the Past

Dear Editor:

Would it be possible for scientists of the future to invent an instrument that could detect and broadcast sounds made many years before?

Gary Forrest
Greensboro, N. C.

Answer. Sound is a form of energy. The propagation of sound waves depends upon the presence of some medium—such as a gas, liquid or solid. Sound waves travel through the conducting medium by setting its molecules in motion. The collisions between moving molecules convert the mechanical energy from the vibrating source into heat energy. Thus energy is not destroyed but converted to heat. It is no longer sound. This is yet another example of the remarkable concept of energy conservation.

However, some forms of energy can be detected a long time after leaving the original source. If tonight is a starry night, step outside. Look up at the stars. Some of the light you see started on its journey hundreds, thousands, and even millions of years ago. When it strikes the Earth and its atmosphere the light too will eventually be converted to heat energy.

Astronomers measure the temperatures of stars by measuring the heat energy which the star radiates. This is done by placing a heat-sensitive device, such as a thermocouple, at the focus of a telescope aimed at a distant star.

Does Hot Water Freeze Faster?

Dear Editor:

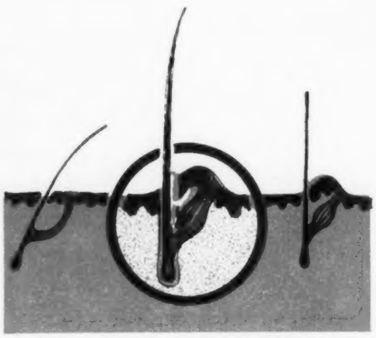
I have always heard that hot water freezes faster than cold. Is this right? If so please explain.

Don Walker
Palm Harbor, Fla.

Answer. This is an old question—good for an argument almost anytime. The best thing to do is test it for yourself.

However, in designing the experiment there are a few rather tricky points that must be handled carefully if your results are to be valid.

Remember that the amount of heat in water is determined by the weight of the water not its volume. Thus, to measure the rate of freezing of two samples of water, you must match them by weight and not volume.



Science World graphic

When you are relaxed, so are hair muscles. Hairs slant toward skin. When you are cold or excited, hair muscles contract, raising hair, and causing goose pimples.

Another thing that may affect the rate of freezing is the amount of dissolved gas. Heating drives some of the gas out of water. Therefore, if you draw two equal samples by weight from the hot and cold water taps, the cold water might have more dissolved gas than the hot water sample. Your experimental design would have to include some way to hold the amount of solutes in the two samples constant.

Suppose that you plan to freeze them in your refrigerator. How could you be sure that the two samples were placed so that the rate of heat loss to the cold air in the refrigerator would be the same?

Finally there is the question of definitions. What do we mean by hot and cold? The results might be quite different from two sets of samples if the temperatures of one set were 2°C. and 98 degrees C., while the temperatures of the other set were 15° and 65 degrees C. Also, what do we mean by freezing? Do we mean the point at which ice crystals begin to form, or the point at which both samples are frozen solid?

Your question is a good one. Let us know the answer.

Heat Conduction in Solids

Dear Editor:

The molecular theory of heat conduction explains why solids are better conductors of heat than liquids and gases, but it does not explain why some solids are better conductors than others. Why is this so?

Vivienne Waho
Piopio District High
New Zealand

Answer. Measurements of the thermal (heat) conductivity of solids give us a clue to the answer to your question. The first interesting observation is that metals conduct heat better than non-metals. Secondly, we find that the solids that conduct electricity well seem also to be good conductors of heat. Conversely, solids that are good electrical insulators are also good heat insulators.

Current theory is that the conduction of both heat and electricity involves the freedom of electrons to drift through solids. Metals such as copper, which have a number of free electrons that can easily drift out of the crystal forms when excited by energy, are good conductors. On the other hand, solids such as diamond, which have all their electrons tightly bound within a crystal structure, are poor conductors. *(See Science World, April 6, 1960, page 36.)*

Thus, if the crystal structure of a solid is such that its electrons are loosely bound and free to move within the crystal, it will be a good conductor of both heat and electricity.

LABORATORY UNDER YOUR FEET

In photo below, once productive muck soil is parched and dry, cracked by heat and drought. Deprived of water, chemical reactions that support plant life fail to work.

U. S. Corps of Engineers

In a complex process, living organisms and the crumbs of disintegrated rock produce the soil that supports the life of the land

By ELIOT TOZER

TO most of us, soil or dirt, as we usually call it, isn't the source of much excitement. There it is, all around us—common, ordinary, and seemingly lifeless. But right there we make our mistake. Soil is not common, far from ordinary, and full of life.

Soil is a chemical laboratory—the Earth's most complete collection of elements and compounds. And in this laboratory beneath our feet, a laboratory without glassware or strange smells, the compounds are being continuously reshuffled. In fact, we would be more accurate if we thought of soil as a *process*, rather than as a material or substance.

What is soil? Where did it come from?

It's a long story, a story that began billions of years ago when Earth's land surface was composed only of crustal rocks. In the billions of years since, many processes and influences have been at work—and are still working—to develop soil.

Pedologists, specialists in soil science, have identified five principal "soil formers" at work: parent rock, climate, time, topography, and biological activity.

Rock, Weather, and Life

All soil is composed of parent material (crustal rock) disintegrated and decomposed by the ever ongoing destructive processes of wind, water, ice, and temperature. These active forces require long periods of time in which to act, and are greatly influenced by the surface forms of the land. Plants, too, are involved. Lichens, which you can find attached to bare rocks, produce acids that react with the rock minerals. These release substances needed to nourish the lichens. At the same time, this process helps to produce soil that will later support other, more complex plants.

Thus rock is disintegrated and decomposed, reduced to particles. Some of the particles are so small that they cannot be seen even with the microscope. Such small particles of soil, which are electrically charged, are called colloids. Colloids do not settle to the bottom in water. They remain indefinitely suspended, knocked about by random collisions of molecules. Colloids play an important role in the chemistry of soils. With their electrical charge they attract and hold ions, the chemical

units of dissolved substances. These tiny particles of rock, literally the crumbs of our planet, become the basis of the soil which feeds the life of the land.

But, you may say, there's a vast difference between the grit of pulverized rock and the crumbly soil of a rich pasture or backyard garden. And you're right. For soil contains two other things that make it different from a pocketful of sand and pebbles. These are (1) the residue of dead plants and animals; and (2) living things: bacteria, molds, and fungi. Worms, insects, and tiny burrowing mammals also play an important role by ventilating and irrigating the soil.

Plant and animal residue and bacteria, interacting with the rock particles, produce the physical and chemical characteristics of good soil.

Bacteria decompose plant and animal matter, releasing water, carbon dioxide, and ammonia compounds. Thus dead leaves, twigs, and the like are reduced to humus. Humus makes soil less dense and increases its capacity to hold water.

It is humus and bacteria that make the difference between a "pocketful of sand and pebbles" and a "dynamic source of life."

They help make the soil a kind of self-sustaining chemistry laboratory. And the chemical behavior of the soil finally determines how well plants grow. To nourish plants, soil must provide for the easy transfer of chemical compounds from the soil to plant tissues.

Fifteen elements are required for plant life. Two of these, carbon and oxygen for respiration, can be taken directly from the atmosphere. The others, including most of the necessary protein-forming elements—nitrogen, hydrogen, oxygen, and sulfur—must be taken from the soil. Soil is also the source of phosphorus, an element essential to most forms of life. However, the presence of these essential elements doesn't necessarily make a soil fertile.

Chemistry of the Soil

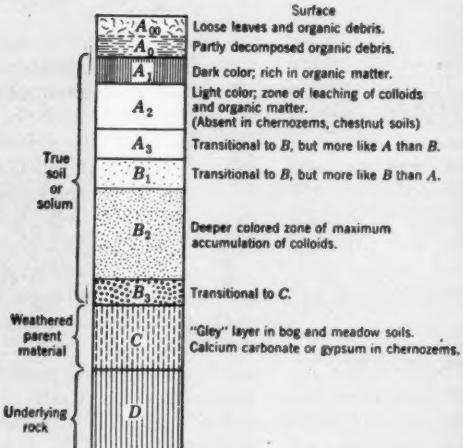
The elements must be in the form of compounds that dissolve in water to form ions, and the elements enter a plant by a complex series of reactions called "ion-exchange." Nitrate compounds formed by nitrate bacteria (see *Science World,* April 20, 1960) break down in solution to form ions. For example, sodium nitrate will yield positively charged sodium ions, and negatively charged nitrate ions. The colloids referred to earlier, which have electrical charges, attract the positive and negative ions from soil solutions.

If the soil has the proper consistency and particle size, so that some of the colloidal soil particles can lie close to the tiny roots, ions from the rootlets will be exchanged with ions on the soil particles. The rootlets may have negative ions. When there is an excess of nitrate ions on the soil particles and an excess of negative ions on the rootlets, nitrates are attracted to the roots in exchange for ions that are attracted to the soil particles.

Another example, positive ions also may collect on the rootlets. Under certain conditions, these positive ions may leave the roots for the soil particles and be replaced by ions of calcium, potassium, or other mineral elements necessary for plant nutrition.

In any well managed laboratory you must have the proper materials, equipment, and conditions to carry out your work. It's the same way with soil—all necessary elements may be present, but if the soil lacks water, proper structure, and particle size, it will not be productive.

It has taken scientists a long time



U. S. Dept. of Agriculture Yearbook

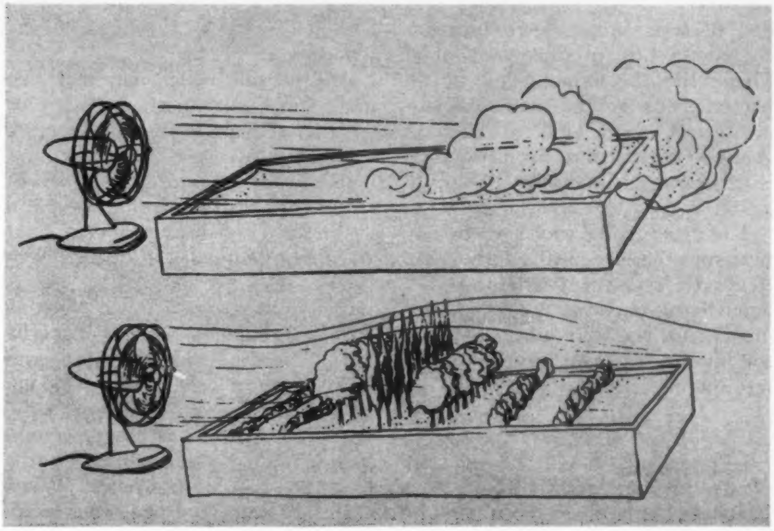
Diagram of a "soil profile" shows that color and make-up of the layers called "horizons" differ with amount of organic material. Upper layers are "true soil." Beneath lies parent rock.

Photo by Ann Ware, SCS.

Actual soil profile shows layer of topsoil rich in organic material atop two layers of loam with decreasing amounts of humus. Under loam, just above parent bedrock, is layer of clay.

to work out the complex chemistry of the soil. Even so, the questions still unanswered exceed by far that which is known.

The first real understanding came in 1840. In that year a German scientist, Justus von Liebig, carefully analyzed soils and plants and stated the "balance sheet" theory of plant nutrition. He wrote: "Crops diminish or increase in exact proportion to the diminution or the increase of the mineral substances conveyed to them by manure." And, in a sense, Liebig was right. But he based his conclusion on the assumption that soils were static, lifeless storage bins. This assumption collapsed when scientists discovered, for example, that clover absorbed nitrogen from the soil, but the amount of nitrogen in the soil was not reduced.



Science World Graphic

Wind is an active agent in the formation of soil. But when the protective cover of grass and trees is removed by poor farming practices, wind may act to destroy the soil. A windbreak of trees provides portection against the loss of precious topsoil.

Error That Bore Fruit

In one of his experiments with soil Liebig found that phosphorus, one essential element, was quickly exhausted from soils. Knowing that bones had large concentrations of phosphorus, he treated them with sulfuric acid and plowed the resulting mixture into the ground. Thus, through an error resulting from the lack of complete data, the concept of chemical fertilization was born. Today it is estimated that chemical fertilizers have increased our food supply by more than 20 per cent.

If chemicals can be added to fertilize the soil, why shouldn't it be possible to find some artificial substitute for humus, the other important soil ingredient? In recent years chemists have developed several groups of chemicals called synthetic soil conditioners. The synthetic soil conditioners are chemical compounds similar to the plastics and synthetic fibers. Chemically, they are long chains of many molecules called polymers (*poly*, meaning many).

When plowed into the soil, these polymer compounds react much as natural soil conditioners do. The synthetic soil conditioners, in contact with water, are capable of holding numerous electrical charges. Sometimes they are called polyelectrolytes. These surface charges attract the charged particles of clay just as if they were magnets. Natural soil conditioners — manures, compost, and plant residues—also bind clay into the structure of soil electronically, to give it the necessary texture.

Field tests performed with the synthetics have not proved them to be an entirely adequate substitute for natural humus. Sometimes, if the soil structure was poor to begin with, the polyelectrolytes bound the soil in that form. In other tests performed by Dr. C. L. Swanson, Director of Soil Research in Connecticut, fields treated with the synthetic conditioners yielded poorer crops than those treated with peat moss—a natural plant residue. But some soils did show increased productivity.

Dr. Swanson pointed out that the chemical structure of the synthetics made them stable and resistant to bacteria. This is on the plus side of the ledger. On the other hand, unlike manures, compost and plant residues, the synthetics contribute nothing to the necessary biological balance of the soil.

Research in the industrial chemical laboratory and in the field will produce better synthetic conditioners and the necessary "know how" to use them well. They may be important in salvaging soils that are now marginal and unproductive, to feed the growing population of Earth. But no matter how much they are improved, synthetics can never substitute for the biological cycles that maintain the ecology of the soil.

In the 1880's it was discovered that rhizobium (*rhizo*, root; *bium*, life) organisms grow in the nodules on the roots of clover and other leguminous plants, and convert nitrogen into forms that plants can use. Not long after, scientists discovered three distinct cycles in the ecology of soil: the nitrogen, carbon, and sulfur cycles. In each, the main element goes through a variety of chemical changes as it passes from the soil into plants as nutrient, sometimes through animals, and eventually back to the soil or air.

Endless Nitrogen Cycle

Here, briefly, is how the nitrogen cycle operates.

Through ion exchange, nitrate is drawn into the plant, along with such nutrients as sulfur and phosphorus. From the nitrate, the plant derives nitrogen to make amino acids. The amino acids enable the plant to produce proteins.

Animals get their nitrogen by eating the plants. Animals break up the plant protein into amino acids and rearrange the amino acids into animal proteins of various kinds.

So there is a steady flow of nitrogen out of the soil into the bodies of plants and then to animals.

But the nitrogen flows back into the soil when the plants and animals

die; bacteria break down nitrogen compounds to produce ammonia. Then other bacteria, called nitrite bacteria, change the ammonia into nitrites. A third kind of bacteria changes the nitrites to nitrates—in which form it can be used all over again.

The cycle is like a closed circular pipe—but there's a "leak" in the pipe. A fourth type of bacteria, called denitrifying bacteria, breaks up ammonia, nitrites, and nitrates in the soil into free nitrogen, and it escapes into the air as gas.

Neutralizing Soil

Nitrogen gas cannot be used by plants. But some, fortunately, is fixed (converted into nitrogen compounds) by the discharge of lightning. More is fixed by the rhizobia. Still more is fixed by certain molds and blue-green algae that flourish in some soils. And so, although the "leak" in the pipe is not stopped, it is compensated for, and life's supply of nitrates is maintained, by one or more of these processes.

Carbon goes through a similar process. Carbon dioxide in the atmosphere is absorbed by plants and converted by photosynthesis into carbohydrates. When carbohydrates are broken down in living tissue or burned as fuels, they again produce carbon dioxide that returns to the atmosphere.

And so, soil, which may look like mere "dirt" or inert particles of weathered rock, is literally teeming with life. It is the most important agent in the continual conversion of mineral compounds from one form to another—and back again—in what we might well call the chemistry of life.

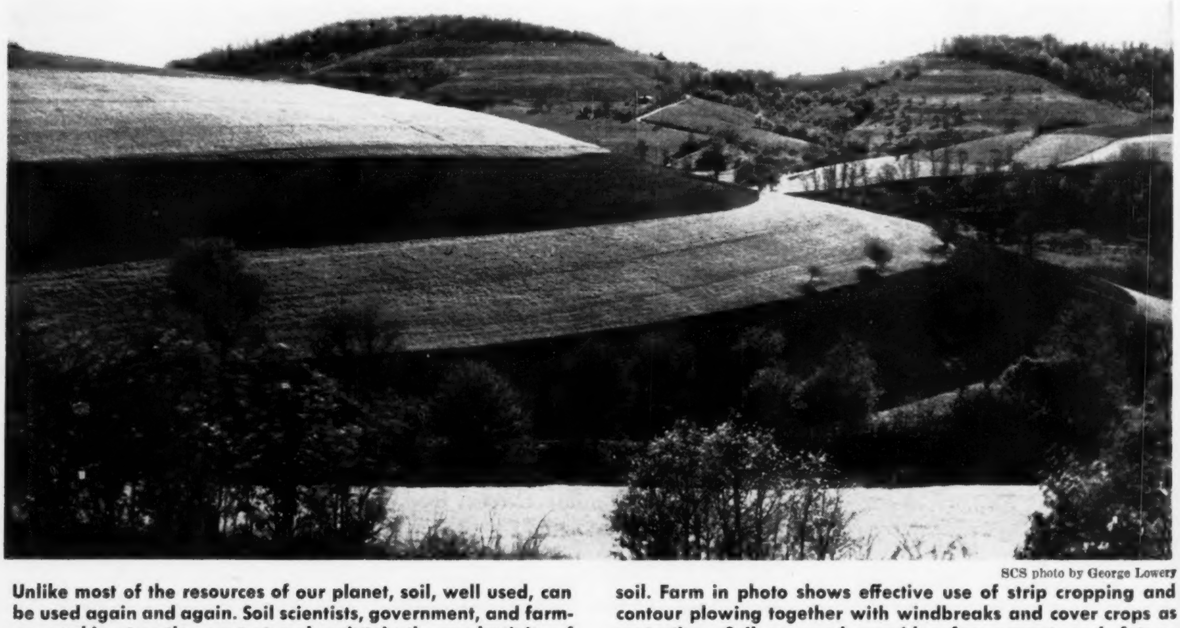
The ability of soil to maintain its chemical balance is truly remarkable. Sometimes this ability plagues farmers. Some soils are "sour." That is, they are too acid for most of the important food and forage crops. Soil acidity is determined by the hydrogen ion concentration. When there are more hydrogen ions available than the other ions can neutralize, soil is acid; when there are few, it is alkaline or "sweet." Too much of either is undesirable. To remedy excess acidity, farmers use lime (a calcium compound) because calcium reacts with water to produce alkalies which neutralize hydrogen ions.

Farmers have found that sour soils always revert to their acid condition. The reason for this is that the clay and humus act as *buffers*. Buffering is a chemical reaction related to ion exchange. This is what happens. Sometimes, when the concentration of hydrogen ions is very high, the colloidal clay particles will pick up the extra ions. A farmer may add lime to his field to neutralize the soil and thus reduce the concentration of hydrogen ions even more. The clay particles will release some stored hydrogen ions. The soil will begin to drift back to its acid condition. Acid soil always requires lime unless enough is added to exhaust the hydrogen ion supply—a most difficult proposition.

Most Precious Treasure

Now, we can begin to see why soil is a process quite as much as it is a substance. In our solar system, Earth is thought to be the only planet able to support the process of soil formation. Other planets probably do not have the required combination of chemical compounds, moisture, and microorganisms.

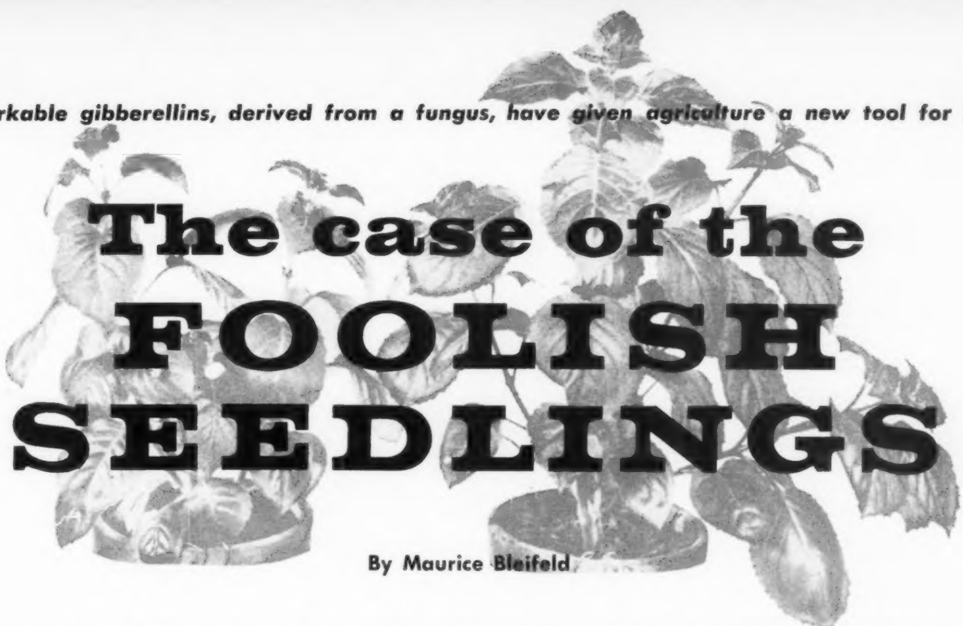
Of all the mineral treasures of Earth, soil is the most precious. It is common on our Earth, and we should be grateful. But soil is not so common that it is inexhaustible. We have seen that the additives provided by man cannot match the complex processes of nature. When next you look up to the stars and dream of man's coming adventure in space, take a second look. Look down at the remarkable chemistry laboratory so close to you—beneath your feet.



SCS photo by George Lowery

Unlike most of the resources of our planet, soil, well used, can be used again and again. Soil scientists, government, and farmers working together protect and maintain the productivity of soil. Farm in photo shows effective use of strip cropping and contour plowing together with windbreaks and cover crops as protection. Soil so used provides for present and future.

The remarkable gibberellins, derived from a fungus, have given agriculture a new tool for research



The case of the FOOLISH SEEDLINGS

By Maurice Bleifeld

WHEN young rice plants are infected with the "foolish seedling" disease they grow extraordinarily long and spindly. The seeds of the infected plants, when ripe, are of poor quality and likely to be sterile—that is, when planted they will not produce new plants.

Bakanae is the Japanese equivalent of "foolish seedling," and the diseased plants really merit the name. Everything about them seems to be wrong. Not only are the stems ridiculously tall, the leaves are longer by far than they should be, and the roots are poorly developed. To top it all off, even the color is wrong. Instead of being a rich healthy green, the plants are pale and yellowish.

What causes the "foolish seedling" disease?

In 1926 a Japanese plant pathologist, E. Kurusawa, working on the island of Taiwan (then under Japanese control and called Formosa), set up a research program to study the disease and its cause. The outcome of Kurusawa's research into the causes of *bakanae* was more than an understanding of what caused the young rice plants to grow in their "foolish" fashion. The Japanese plant pathologist isolated some most unusual chemicals.

These unusual chemicals are called gibberellins.

In some cases the gibberellins make plants grow remarkably tall in a very short time. In other cases their effects are even more startling. They make garden plants produce flowers well ahead of their time. They cause fruits to develop without the normal effects of pollination. They make dwarf plants grow to the size of normal plants. Seeds soaked overnight in a solution of these chemicals germinate ahead of time. Their effect on biennial plants is such that instead of taking two years to produce flowers, they burst into bloom in one year. Tree buds that normally must go through a winter of coldness for normal development sprout freely in a short time.

If you haven't come across the gibberellins yet, it is because they are just beginning to attract attention. Although first discovered in Asia by a Japanese scientist more than 30 years ago, they remained unknown to the western world for the next quarter of a century.

Curtain of Silence

There were two probable reasons for this unusual curtain of scientific silence. First, the experiments were described in Japanese, a language unknown to nearly all of our scientists. And then, the outbreak of World War II prevented the cooperation of Japanese and American scientists.

Even before 1926, scientists in Japan and the other rice-growing countries had known that the symptoms of *bakanae* appear when rice seedlings become infected with a fungus known as *Gibberella fujikuroi*. Careful study of this fungus showed that it was not an independent species but the reproductive stage of another fungus, *Fusarium moniliforme*. The gibberellins, however, have created so much interest among plant scientists and agriculturists that the name resulting from the scientific error will be a permanent addition to our scientific vocabulary. Most mistakes are not treated so well.

Kurusawa wanted to know just how the fungus infection produced the "foolish seedling" symptoms. To find out, he first grew the fungus in pure culture, on liquid food in a flask. After some time, he filtered the liquid. Then he applied some of the filtered liquid to healthy young rice plants. He noticed that after a while these plants began to show the symptoms of wild growth characteristic of "foolish seedling diseases," *even though there was no mold present.*

Kurusawa reasoned that the liquid contained a substance given off by the fungus, which was able to produce the *bakanae* effects on the healthy plants. He then embarked on a series of experiments to find out more about this substance. Soon he learned that it was not affected by freezing, sunlight, steam-pressure sterilization, and short exposures to ultraviolet light—whatever it was, it was stable in most conditions provided by nature.

By this time, Kurusawa's work was attracting attention in Japan's scientific centers. A group of scien-

tists at the University of Tokyo began to study the powerful substance. In 1935, after purifying and isolating the substance, one of the scientists, T. Yabuta, named it gibberellin—from the name of the mistakenly classified fungus. In the years that followed, up through and after the entry of Japan into World War II, these scientists continued their work. They discovered that gibberellin was not a single substance. Of several active agents, they were able to identify three: gibberellin A, and gibberellin B, and gibberellin C.

All during this time, the western world was unaware of the existence of the gibberellins. It was not until after the war, in 1950, that the first

Tall stems, a characteristic of gibberellin treated plants, are shown by these 12-foot cabbages grown at U. of Michigan.

Chas. Pfizer & Co. Inc.

American research on this new substance was announced by two plant physiologists at Camp Detrick, Maryland—J. E. Mitchell, and C. R. Angell. In one of their experiments, they dipped the upper part of young bean plants into a solution containing the gibberellins. They were fascinated to observe that the plants had grown 500 millimeters (about 20 inches) beyond the primary leaf. By comparison, the normal and untreated controls had grown only 35 mm. (less than 1½ inches).

Gibberellins Come West

This was the beginning of active scientific interest in the gibberellins in this country. Intense work was done on the chemical constituents of the new substance. Soon additional chemical factors were isolated and purified. It is now known that at least six different gibberellins are produced by the fungus. One of them, for example, is gibberellic acid, $C_{19}H_{22}O_6$.

Because of their effect on growth, it was at first thought that the gibberellins might be varieties of growth-promoting hormones normally produced by growing plants. However, a study of their chemical structure showed that gibberellins are unlike any previously identified plant substance. In no way do they resemble the growth hormones produced by normal, healthy plants.

As more and more of the crystalline gibberellins became available, their effects were studied on a great many plants, in the hopes of developing bigger and better crops. In some cases, the results have been quite dramatic. In others, much additional work remains to be done.

In general, it has been found that corn, wheat, tobacco, tomato, cucumber, and more than a hundred other species of plants grow more rapidly when treated with the chemical. They often show an increase in height that is three to five times the normal, within a two- or three-week period. Anyone seeing this spectacular growth for the first time is almost bound to think of Jack and the Beanstalk.

One interesting line of research has been carried on with a variety of corn that never reaches normal height. This dwarf corn owes its stunted growth to an inherited recessive gene. Treatment with minute amounts of the gibberellins causes these dwarf plants to grow to normal size.

In a similar type of research, dwarf pea plants, which ordinarily do not grow taller than a foot and a half, showed a difference of 500 per cent in their growth within a few days following one treatment. They continued to grow until they were about six feet tall.

It was originally thought that the action of the gibberellins resulted only in increased stem length, but other unusual, almost fantastic, effects have been discovered.

One of these strange effects has been observed in the case of the foxglove and the carrot. These plants have a two-year life cycle, and are known as biennials. During the first year of growth, these biennials produce a low-growing group of leaves. Food is stored in the root. In the winter the plants seem to die off. However, in the spring of the second year they again sprout and give rise to tall plants that produce flowers and seeds.

When such biennial plants are treated with the gibberellins early during their first year, they grow into tall plants and burst into bloom—an event that normally occurs only in the second year.

Another interesting effect of the gibberellins has been observed in potatoes. Potato farmers do not ordinarily plant seeds. Instead, they cut up the potato tubers, called "seed" potatoes, into a number of pieces, making sure each piece contains at least one "eye" or bud. When planted, the "eyes" sprout and develop new plants, obtaining their nourishment from the food stored in the slice of potato.

Wake Up, Bud

The farmer knows from experience that potatoes planted directly after a harvest fail to sprout for weeks. They are in a state of rest or dormancy. Therefore, he allows his potatoes to "ripen" before cutting them up for planting. When treated with gibberellins this resting period is broken and potato plants start to grow immediately.

Similar cases of dormancy broken by gibberellins have been observed in other plants. Apple seedlings have

been developed from seeds which were not subjected to the period of "cold-ripening" normally necessary for them to germinate properly. The dormancy of tree buds in winter has also been broken by treatment with gibberellins.

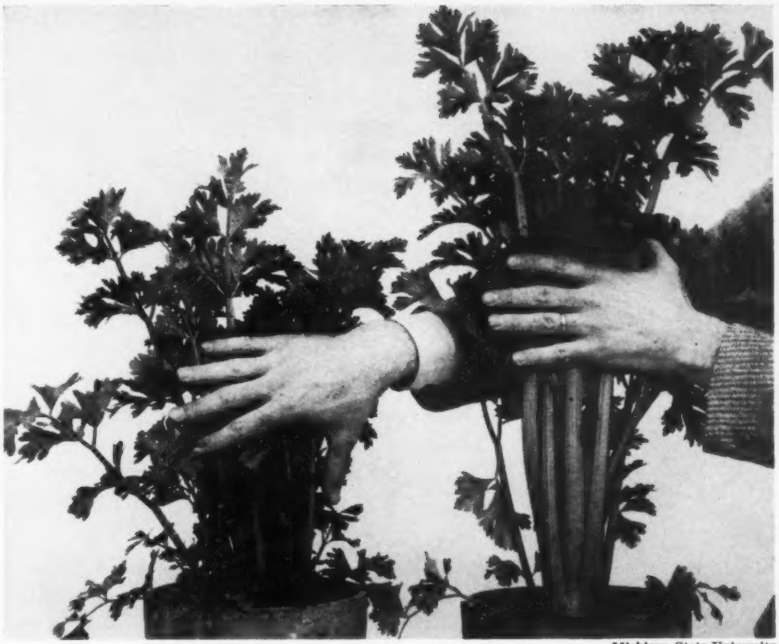
Gibberellins have also been found to have stimulating effects on some types of seeds. Seeds of peas and beans were soaked overnight in water solutions containing 50 parts per million of gibberellins. When these seeds were planted, it was found that two interesting results were obtained: the seeds germinated more rapidly—in some cases, three days earlier. Also, after the seedlings had emerged, they grew more rapidly than the untreated control plants.

Seedless Tomatoes

Among the most remarkable effects of gibberellins is their ability to cause flowers that have not been pollinated to produce fruit. In experiments with tomatoes, normal appearing fruit has been produced when solutions containing from 2 to 1,000 parts per million of gibberellins have been sprayed on the blossoms. Some of the tomatoes were entirely without seeds—which should prove to be a great boon to salad eaters and pizza sauce makers. The use of gibberellins to hasten fruiting appears promising, according to Dr. S. H. Wittwer of Michigan State University. The treatment does not seem to harm the leaves or deform the fruit in any way. The only question that still bothers scientists, and no one seems to have the answer, is —are the tomatoes good to eat?

In other cases, cucumbers and eggplants have also been produced without pollination, simply by spraying the plants at the right time with gibberellins.

Although the esthetic effect is doubtful, the desire of every gardener to produce bigger and earlier flowering plants than his neighbor may now be close to realization. When geranium buds were sprayed just as they were showing color, the resulting flowers were doubled in size. African violets, which sometimes cause feelings of frustration because of their delicacy, have been speeded into blooming. Pansies have bloomed months earlier. Even petunias have been induced to bloom during the short days of mid-winter.



Michigan State University

Effects of gibberellins on celery may aid farmers to produce a marketable crop 2 to 3 weeks earlier than usual. Plant at right was sprayed with solution containing 100 parts per million 4 weeks prior to photographing. Compare with control plant at left.

Most of the work with gibberellins has been done by agricultural scientists or by commercial greenhouse operators. Tomorrow's scientists can avoid duplicating the earlier experiments and may make an original contribution to man's knowledge by working with less common plants. The lower plants—such as ferns, liverworts, mosses, molds, mushrooms and algae—all offer a fairly "wide open" field for investigation.

In addition to gibberellins, which may be obtained from the sources listed at the end of this article, the equipment required is simple. You will need a good balance (obtainable in school), some four-ounce stock bottles, a graduate, two atomizers, and a notebook.

If the commercial preparation used contains both gibberellin and filler, it will be necessary to assume that the filler is inert and has no effect on the plants.

Suppose that the product you start with has about 0.2 per cent of active gibberellins. If you weigh out 2.5 grams of the gibberellin compound and dissolve it in 50 cc of water you will have a solution containing 0.1 milligram per cc. Ten cc of this solution will contain 1 milligram or 100 parts per million. Take 5 cc of this solution and place it in another bottle with enough water to make 50 cc. This solution will contain 0.1 mg in each 10 cc—its strength will be 10 parts per million. By taking 5 cc of this last solution and diluting it to 50 cc, you can prepare a dilution of 0.01 mg per 10 cc. Following the same procedure, you can prepare solutions so that each 10 cc will contain .001 mg, .0001 mg and .000001 mg of the active gibberellins.

Controls Tell the Story

Here are the directions for a simple project to demonstrate the effectiveness of gibberellic acid with pea plants. Germinate 12 plants of the same variety of pea in individual paper cups filled with a mixture of topsoil and sand. When the plants start to sprout, and are about one inch tall, spray four of them with 10 cc of a solution containing 100 parts per million of gibberellic acid. Use an atomizer or apply the solution to all the surfaces of stem and leaves with a medicine dropper.

(Continued on page 31)

The forces of magnetism are complex, but as we find out more and more about them, magnets may become smaller and smaller and more powerful

By SIMON DRESNER

OUR TINIEST MAGNETS

AT the beginning of World War II, German airplanes dropped some strange-looking objects into the mouth of the Thames River, in England. After hitting the water, the objects, full of explosives, sank to the bottom. In each of these objects, which were none other than mines, was a tiny magnetic needle that aligned itself with the Earth's magnetic field as the mine settled on the bottom.

If a metal ship passed nearby, the iron in the ship distorted the Earth's magnetic field and caused the magnetic needle to dip a little. This movement of the needle closed an electrical circuit which exploded the mine under the ship.

Scientific studies during the war showed that part of the magnetization of a ship occurred when the ship was assembled. The heat and impact of the riveting caused the ship's plates to be magnetized in the direction of the Earth's magnetic field at the point of assembly. This made the whole ship a permanent magnet, of sufficient strength to explode the German magnetic mines.

Scientist measures the magnetic field strength between the poles of a large electromagnet with a Gaussmeter. Magnetic field twists rod, turns pointer against spring.
General Electric photo

One method used to combat these mines was a magnetic minesweeper. This was a large ship carrying a very strong magnet weighing many tons. It was usually a bar magnet running from the bow of the ship to the stern, magnetized by coils of wire wrapped around it, carrying current from large generators aboard the ship.

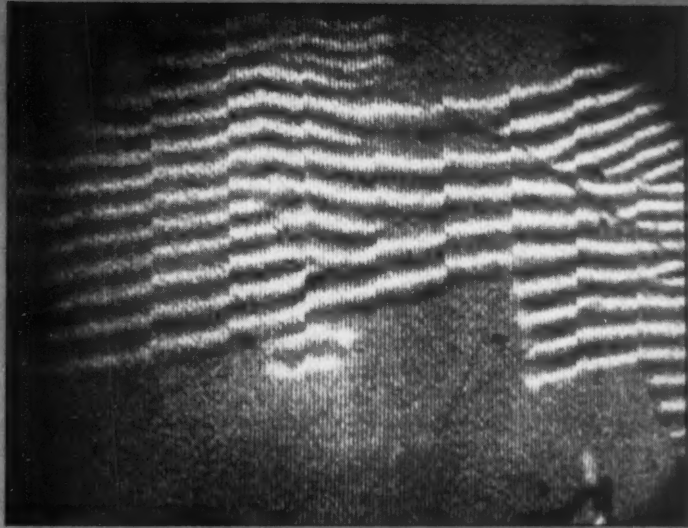
The magnet was intended to produce magnetic fields ahead of the ship, so that as it steamed around the harbor it would explode magnetic mines before the ship actually was on top of the mine.

Both the permanent magnetism of metal ships and the magnetism of the large magnet aboard the magnetic minesweeper are the same as the magnetism of the familiar bar magnet or horseshoe magnet. The laws which govern magnetic materials are the same for huge magnets as well as for tiny ones.

Each Electron a Magnet

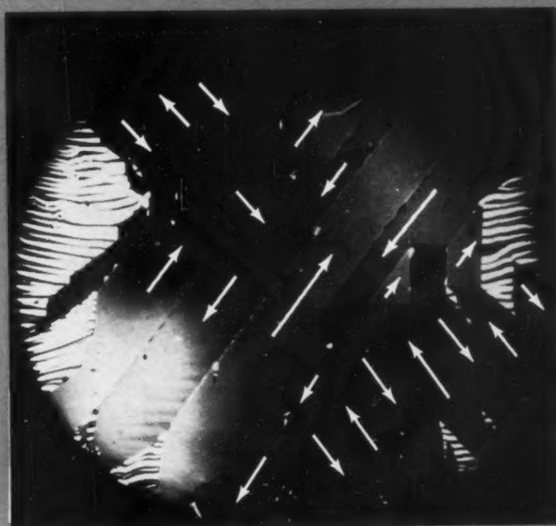
The forces which make a bar of iron or other metal a magnet are very complex, but all magnetism is based on the spin of electrons. Every spinning electron in the shell of an atom behaves as a tiny permanent magnet. The direction of spin determines the polarity of the magnet. The magnetic strength of a spinning electron is defined as one Bohr *magneton*, after the chemist Niels Bohr who theorized the structure of electron shells.

A complex atom, such as iron, has many spinning electrons distributed in shells around the nucleus. Nor-



Westinghouse "Lab 30"

Pictures taken with polarized light show magnetic domains—tiny magnetized regions in magnetic material. Domain boundaries can be seen as slight up and down shift of stripes. The shift is caused by the light. The first pictures of this phenomenon were taken for Westinghouse's "Lab 30" TV show.



Westinghouse "Lab 30"

Magnetic domains in a single garnet crystal, photographed with polarized light through a microscope. Each white or black region represents a group of atoms whose electron spins create a magnetic field in direction shown by arrows.

mally the magnetic effects of all these electrons cancel each other out, because the electrons in the atom usually appear in pairs, spinning in opposite directions.

However, when an atom has an odd number of electrons, or when a group of its electrons spin in the same direction, then the atom as a whole behaves as a magnet. In the iron atom, for example, the spin of electrons cancels out except in the next to the outermost shell. In this shell, however, five spins in one direction are countered by one spin in the other direction, leaving a net magnetic effect of four Bohr magnetons.

There are many materials which have such an imbalance of electron spin, resulting in atomic magnets. Such materials are called *paramagnetic* substances. However, the fact that a material's atoms are magnetic does not necessarily make it a magnet.

Magnetic Domains

The electrons in a paramagnetic substance are free to turn independently. They can turn quite violently as a result of thermal motion of the atoms, and are knocked about at random.

As long as the magnetic atoms take random positions, there is no magnetic effect. To make the material magnetic, some force must align the atoms so that the direction of their magnetic forces coincides. This can be illustrated by thinking of the atoms as a number of small compass needles piled into a box. If the box is shaken up, the needles will all point in random directions, and no magnetic field will exist around the box. However, if the compass needles are stacked so that all their north-seeking poles face in one direction, the box will act as a large magnet.

To make a magnet of magnetic material, the force which lines up the atoms must be greater than the thermal forces which tend to disarrange them. When a material is heated to the point where the thermal motion overcomes the aligning forces, the material loses its magnetism. For iron, this critical temperature is at the red heat of 1420 degrees F. (800 C.). It is called the Curie point after Pierre Curie, the French scientist who discovered it in the last century. He made measurements on magnetic materials at high temperatures and found that the critical temperature for nickel is 350 C. These temperatures give a good indication of the relative strength of the aligning forces in iron and nickel. All ferromagnetic substances are characterized by their Curie temperatures.

Ferromagnetic materials include iron, cobalt, nickel, gadolinium, and many alloys and compounds of these elements, as well as manganese, chromium, and others. These differ from paramagnetic materials in that when they are brought into a magnetic field between the poles of an electromagnet, they are strongly affected, while paramagnetic materials are weakly affected, if at all.

But why should iron and other ferromagnetic substances be more strongly affected? According to concepts of the atomic magnets, all paramagnetic materials with the same number of Bohr magnetons should be equally affected. The aligning forces in iron atoms could not possibly be much stronger than those in ordinary paramagnetic substances. Furthermore, if atomic forces tell the whole story, why doesn't a piece of iron spontaneously become a magnet, since its little compass needles would tend to line up? Why does it become a magnet only after being magnetized by an electric current or another magnet?

Obviously the concepts of interatomic forces only partially explain the phenomena of magnetism. A more complete theory was worked out by the French Physicist Pierre Wiess many years ago. He realized that just as electron magnets and atomic magnets can neutralize each other, so could larger units within the material. He suggested that iron, for example, is composed of many small magnetized regions called *domains.*

Each domain is a region up to thousands of atoms thick, corresponding to an individual "compass needle" in the box of needles mentioned previously. The iron is magnetized when an outside force lines up the domains in the same direction.

The domains are separated by "walls"—actually only boundary lines where the atoms turn from the direction of one domain to the direction of the next domain.

Making Domains of Powder

Can these magnetic domains be observed? The first experiments in making the domains visible used very fine magnetic powders sprinkled over the magnetized material. Just as in a large magnet the magnetic field is concentrated along edges and sharp corners, so it would be expected that the magnetic field of the domains would be concentrated at the edges of the crystals which compose the domains.

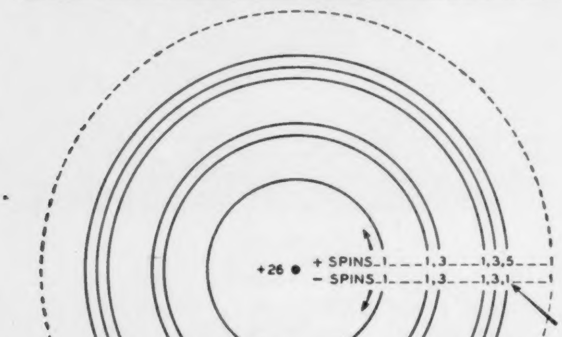
One technique succeeded in outlining the domains with particles of iron oxide in colloidal suspension. This allowed scientists to observe the behavior of the domains when they were subjected to a magnetic field, to see what goes on inside a magnet.

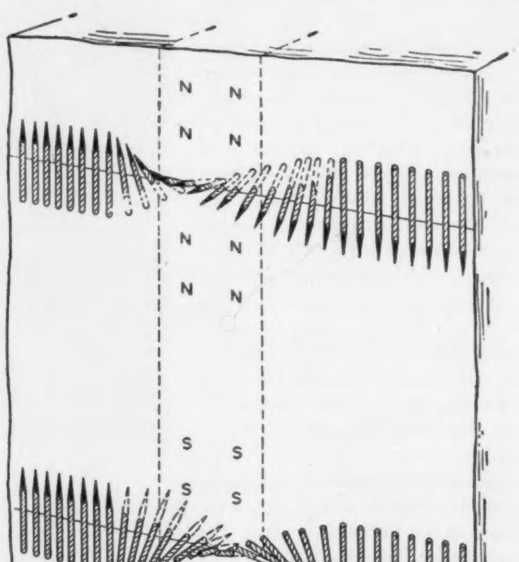
By making the domains visible, it was found that when a weak magnetic field is applied to a piece of iron, its domain walls are shifted, and the domain is enlarged by the addition of atomic magnets (from adjacent domains) whose poles are nearly parallel to the field. The domain grows at the expense of other domains whose atoms are oriented less favorably, resulting in an overall increase in magnetism.

Rarely are all the domains in a block of iron oriented in the direction of the magnetic field. If a block of iron were magnetized as a single large domain, that is, having all its atoms in alignment, it would have a very strong magnetic field. Because of many disruptive interatomic forces, such an alignment into a single domain is impossible.

When a piece of iron is magnetized, its dimensions change slightly. This phenomenon is called magnetostriction. Now, if several domains are magnetized, their dimensions might

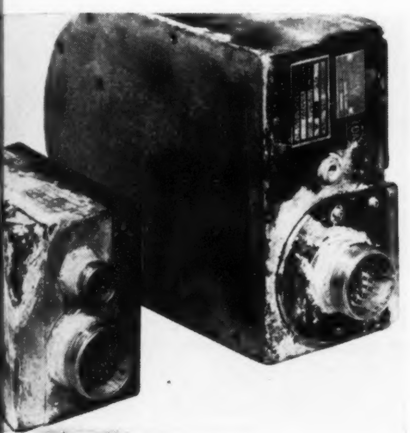
Structure of iron atom shows why iron is magnetic. Electrons in shells around nucleus have positive or negative spins. Effect of spins cancels out, except in next to outermost shell, leaving a net magnetic effect. Electron spin is basis of all magnetic materials. Groups of atoms with magnetic spin effects in same direction form a magnetic domain. Schematic at right shows boundary between two domains and change in the direction of spin orientation on either side.
Bell Telephone Labs drawings





Ampex photos

Magnetic tape recorders have become invaluable research tool in recording and storing information on flights of rockets and satellites. Miniature tape recorder above was sent up in high-altitude rocket which later crashed on Earth. Battered recorder, below, survived crash, yielded valuable information.



change, and they might no longer fit in the space they previously took up. This tends to set up strains or deformation in the material. Additional energy is required to magnetize the material.

Iron, which has cubic crystals, has six possible directions of magnetization. Cobalt, on the other hand, has only two possible directions of magnetization, and domains in a piece of cobalt are like magnetized needles which can point to only two opposite directions. Therefore, it is somewhat easier to align all the cobalt domains in a single direction to make a strong magnet.

But in all natural magnetic materials, the movement of the domains into positions of alignment is limited by the space in the crystal structure which allows the domains to twist and turn. This led scientists to the idea of making their own domains with very fine powders, and pressing the powders into a solid while under a magnetic field. This would make very strong permanent magnets, since most of the domains would be aligned in the direction of the field. Such pressed powder magnetic materials are called ferrites.

Ferrites of iron oxides combined with oxides of other metals have many advantages over simple metals as magnetic materials. Not only do they make very powerful magnets, but they have a high electrical resistance. This is important for electric power applications, as in transformers, where a great deal of energy is lost in currents which flow through the magnetic material in the core. In transformers with ferrite cores, these eddy currents are minimized. The resistance of ferrites is more than a million times greater than that of other transformer materials.

Magnets at Work on Tape

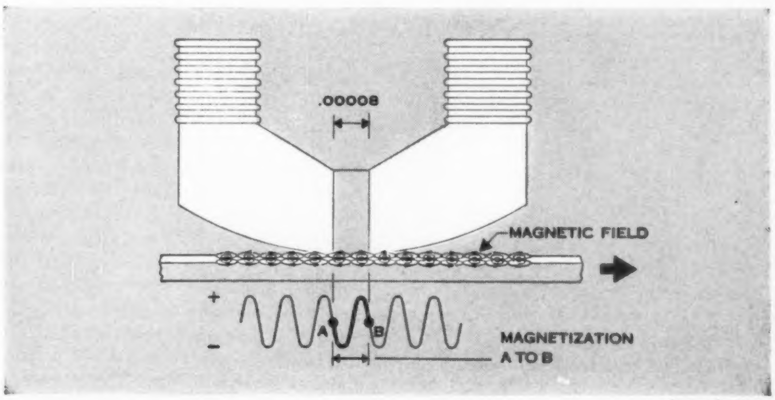
The ferrite magnets are also being used in radio and television, where eddy currents could distort the delicate and precise signals required.

Ferrite magnets are made by powdering the oxides of nickel, zinc, iron, manganese, and other metals, then pressing the powder to the desired shape with binding resins, and firing it. A great deal is known about the technology of the ferrites, but as answers are found for the unanswered questions on the nature of magnetism, smaller and more powerful magnets, with undreamed of properties, may be discovered.

One of the most revolutionary developments in the use of magnetic materials has been the magnetic tape recorder. This machine, familiar to hi-fi enthusiasts, uses a roll of plastic tape coated with powdered magnetic iron oxides. The tape is pulled past a magnetic recording head, which translates electric impulses into tiny magnetized regions on the tape. When the information on the tape is to be played back, the tape is pulled past a similar playback head, which translates the magnetized spots on the tape into electric impulses.

The great advantage of the magnetic tape recorder over other means of recording is the speed and ease with which the recording can be made, and the large amount of information which can be stored in a small amount of material. The latest development in tape recorders, the videotape, can store complete TV programs in a reel of magnetic tape. Tape recorders are also recording the tremendous amounts of data required by space scientists to test rockets and space vehicles. They are also used in electronic computers to store the thousands of bits of information in the computer memory.

These fabulous uses have come about only in the past ten years, when the magnetic tape recorder first became practical. In the future, there is no telling what new and wonderful uses will be found for magnetic materials.



Ampex drawing

Tape recorder uses magnetic tape pulled past poles of electromagnet. Powdered iron oxide on tape is magnetized in small areas, depending on current flow in magnet.

Science in the news

Keep Germs off Moon

When the U. S. lands a 300-pound seismograph on the moon in two or three years, the instrument will be completely sterile and germ-free.

The sterility of the instrument package is designed to prevent accidental contamination or "infection" of any organic material—alive or dead—which may exist on the moon. Bacteria from the Earth could wipe out important clues to the early history of the solar system and the origin of life on Earth.

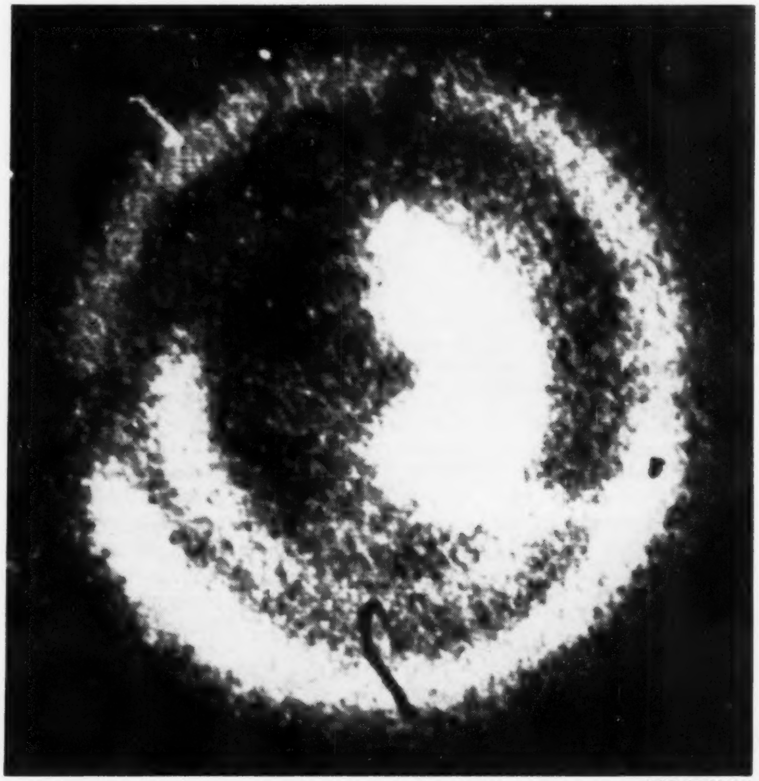
Recent evidence suggests the moon may once have had an atmosphere similar to that of the Earth. The long chain of chemical events which led to simple organic molecules and primitive forms of life, may have been duplicated on the moon until its atmosphere escaped into space. This organic material, dead or alive, may subsequently have been buried by layers of lunar dust created, it is believed, by the impact of meteorites. With loss of the moon's atmosphere, the searing heat, bitter cold, and killing radiation of outer space would have destroyed organic molecules on the moon's surface.

However, buried layers of organic material laid down billions of years ago might preserve a record of life obliterated on Earth long ago.

If a rocket landing on the moon penetrated these layers, organisms carried from Earth might possibly find enough heat and moisture to grow explosively and destroy the age-old record.

To avoid this possibility, scientists are planning to sterilize the moon seismograph and other instruments to be landed on the moon to record "moonquakes." Neither heat, cold, cosmic radiation, or ultraviolet radiation will destroy all the bacteria aboard a space vehicle. Army researchers at Fort Detrick, Md., have come up with a powerful gaseous disinfectant, ethylene dioxide. The moon probe payload might be sprayed with the chemical just before takeoff. However, this would still leave the problem of sterilizing the thousands of individual components inside the instrument package.

It is even possible that all these measures may be too late. Soviet scientists contend that the rocket and payload which they crashed on the moon September 13, 1959, had been sterilized. However, no details of the sterilization techniques were given by the Russians.



Wide World photo

X-ray photo of sun was taken from rocket at altitude of 130 miles. Photo shows sun as it would appear to our eyes if they were sensitive to X rays. Photo was taken by pinhole type camera (no lens). Black blotch and J-shaped marking are film flaws.

Sun X-Ray Photo

Photos of X rays from the sun taken by a battery of six rocket-borne cameras show the sun ringed by a bright halo of X rays.

The pictures could not be taken from the Earth's surface, because most X-ray radiation reaching the Earth is absorbed in the upper atmosphere. (This absorption creates belts of ionized air that make possible long-range radio transmission.) Therefore, the pictures had to be taken from a rocket at an altitude of 130 miles. They show the sun as our eyes would see it if they responded to X rays rather than to the longer wavelengths of visible light.

Since X rays will pass through glass unrefracted, a glass lens cannot be used to focus X rays on film. The scientists, therefore, had to use a modified pinhole type of camera which has no lens at all. In such a camera, only a single beam of light (or X rays) from each point on the object can pass through the hole, thereby forming a point-to-point relationship between the object and the image on the film.

In the X ray camera, the hole was 0.005 inches wide, and covered with an extremely thin layer of aluminum on a thin plastic sheet. The aluminum screened out visible light, which would have blackened the film, but was thin enough to be transparent to X rays.

The pictures show that most of the solar X rays come from the corona surrounding the sun's central mass. Large quantities of X rays produced within the sun are reabsorbed in the outer layers of the sun itself. They remain invisible, except during storms, such as the one near the center of the photo. The black blotch and J-shaped marking are film imperfections. The project was carried out at the U. S. Naval Research Laboratory, under the direction of Dr. Herbert Friedman.

Polio Strikes Back

Is the Salk vaccine losing its effectiveness?

In 1957 there were fewer than 6,000 cases of polio in the United States. This represented a drop from almost 20,000 cases, reported in 1955. It seemed to doctors and parents everywhere that the Salk vaccine tested in 1954-55—and proved from 80 to 90 per cent effective in preventing polio—had dealt a blow to the disease.

But in 1959 the number of cases jumped to more than 8,000. The number of paralytic polio cases among them reached the dismaying number of 5,694.

Is there some new type of strain of the virus against which the vaccine does not protect?

Epidemiologists, scientists who study the transmission of disease, have some tentative answers. In the first place, two facts suggest a new strain. These are the sharp rise in the percentage of paralytic cases among the total number of cases, and the fact that certain groups of the population seem to suffer more cases than others. Polio used to strike one and all alike.

The group most severely hit are children under two years of age. The scientists have also noted that slum dwellers, Indians on reservations, members of certain religious sects who prefer to keep to themselves, and people in military housing developments seem to be getting more than their expected share of the cases.

However, Dr. Russell Alexander and Dr. Alexander Langmuir, epidemiologists of the U. S. Public Health Service, have found that most cases of the disease occur among those who have not had a full course of polio shots. Fewer than two per cent of all cases occurred among those who had three shots. This seems to indicate that the vaccine is still functioning well within its predicted range.

Dr. Alexander and Dr. Langmuir are of the opinion that "soft spots" in the vaccination program are at fault. The largest number of cases are among those people who for lack of education, indifference, or beliefs about shots and vaccination, fail to make full use of the vaccine.

The Salk vaccine has been proved effective and is widely available, but there are still more than 91,000,000 "holdouts" who have not had a single shot, according to the scientists.

Brain "Thermostat"

After eating a pound of sherbet, Dr. Theodore H. Benziger slipped into a coffin-like box and discovered that body temperature is controlled by the brain, and not the skin.

Dr. Benziger discovered that the "thermostat" which keeps body temperature constant is located in the brain, and has little to do with the temperature of your skin.

The box he climbed into was a calorimeter, an extremely sensitive device designed to detect heat flow into and out of a human body. In addition, the scientist had tiny thermometers taped into his nose and ears.

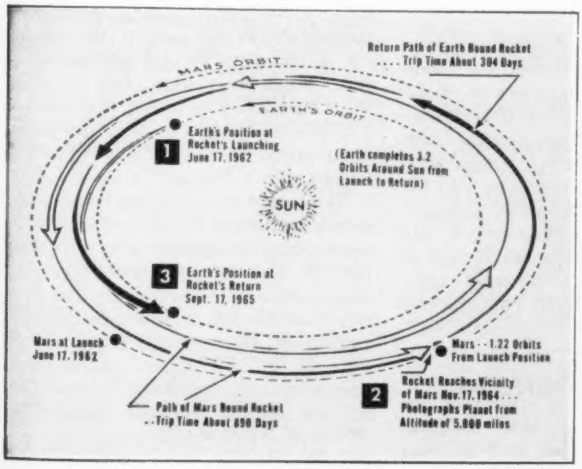
Before Dr. Benziger ate the sherbet, his skin temperature was 99.68 degrees F. He was perspiring normally, and his blood temperature was 98.6, as measured by the thermometers in his nose and ears. After eating the pound of sherbet, however, his blood temperature dropped considerably. This caused the "thermostat" in the brain to shut off the perspiration, although his skin temperature remained high.

Dr. Benziger measured the blood temperature at which his sweating thermostat kicked off: 97.24 degrees F. He repeated the measurements on the nation's seven astronauts, whose kickoff temperature ranged between 97.61 degrees and 98.33 degrees.

From this the scientist concluded that the thousands of temperature sensitive regions in the skin tell you only how hot or cold it is outside your body. But the temperature center in the brain measures how hot or cold it is inside your body, and thus does something about it. If it is too hot, the brain center "sets off" the sweat glands, cooling your body through evaporation. If it is too cold, the brain center makes you shiver, warming your body through muscular motion. Up to now, it had been believed that the brain was activated by the skin temperature, which sent electrical impulses along the nerves.

To Dr. Benziger, this seemed like having the thermostat of a house located outside the house, instead of inside. It would react to outside agencies in climate rather than to the temperature changes inside the house.

This explains why you start sweating when you drink a cup of coffee, even if the outside air is very cold. The experiments were carried out at the Naval Research Institute, at Bethesda, Md.



UPI drawing

Interplanetary space probe, designed to make three-year trip to Mars and back, would take detailed photos 5,000 miles from planet. Rocket would leave June '62, return Sept. '65.

Wide World photo

This is model of Mars space probe camera, which may come close enough to planet to detect signs of life. Probe would land in Gulf of Mexico within 10 minutes of scheduled time.

Science in the news

Cosmic Rays Theory

The energetic cosmic rays found in space may have their origin in giant shock waves set off by exploding stars.

This theory was developed by Dr. Stirling A. Colgate of the Lawrence Radiation Laboratory at Livermore, California. The theory grew out of speculation on what would happen if a hydrogen bomb were exploded in outer space.

According to Dr. Colgate's theory, the cosmic rays are created in supernovae—stars which explode with a force of more than a billion billion billion hydrogen bombs. His theory explains why the cosmic rays have energies as high as several billion billion electron volts.

The explosion inside a supernova occurs in a tenth of a second. The pressure of the explosion is propagated to the outer layers of the star by a shock wave. As it reaches the less dense outer regions of the star, the shock wave picks up speed, until it is traveling at nearly the speed of light—186,000 miles per second.

The shock wave excites the outer material of the star to temperatures of one billion degrees. Some of this excited matter, such as the proton nuclei of hydrogen atoms, is shot out into space to become cosmic rays.

Two measured characteristics of cosmic radiation strongly support this theory. The distribution of elements observed in cosmic rays corresponds with the theoretical distribution of elements on the surface of supernovae. Also, the observed intensity of cosmic radiation corresponds to the theoretical intensity expected in exploding stars. Supernovae explosions occur about once every hundred years in a galaxy. Over the lifetime of a galaxy, therefore, there would be a few million supernovae explosions, enough to fill the galaxy with the amount of cosmic rays presently observed.

U. S. Air Force photo

Thermoelectric refrigerator in space capsule model will be used by astronauts to cool food. It has no moving parts, would operate in weightlessness of outer space.

Air Ions and Health

Ions—electrically charged atoms—in the air have an effect on the functioning of the human body.

Both positive and negative ions are found naturally in air. The discovery and explanation of their effect on human tissue may have considerable medical importance. The reason? Negative ions seem to have a beneficial effect. They stimulate the cilia and mucus of nose and throat, and help to keep the lungs and sinuses free of foreign particles.

Civilization, with its smogs and electronic gadgets, tends to increase the number of positive ions in air. Positive ions have an adverse effect. They reduce the efficiency of the cilia, which are tiny hair-like projections on cells lining the nose and throat. Cilia, along with the mucus, trap foreign particles and "sweep them out."

Scientists at the Berkeley Campus of the University of California have found that the action of a hormone from the nerve tissue, serotonin, will produce the same adverse effect as positive ions. They have also found that dosage with tranquilizing drugs counteracts both the effects of serotonin and positive ions.

The scientists were then able to turn around information to produce some of the beneficial effects of drugs by exposing patients to negatively charged oxygen ions.

War with Gooneys

The Navy's Pacific War with the gooneys may be nearing its final phase with a Navy victory in sight.

The gooney birds are blackfooted albatrosses that nest on Midway Island, a key Pacific airbase, 1,150 miles northwest of Honolulu. Midway is home to more than 520,000 black-footed albatrosses.

The trouble comes from the gooney's habit of soaring over the airfields. In one 12-month period, there were 538 bird-plane combats with no fatalities—except to the birds. Cost of repairing planes—$158,000.

Fearful of more serious accidents, the Navy has resorted to just about every bird-frightening trick known. One plan was to transport the birds to far places. But a selected group of gooneys, carried across the Pacific to the Aleutians, showed up at Midway, a tiny dot in the Pacific, a few weeks later—apparently having benefited from the exercise. Weird noises, smoke, egg stealing—even extermination—did little to discourage the gooneys.

Now, at the suggestion of biologists, the sand dunes which create air currents and thermals favorable for soaring and gliding are being leveled. Since last November, the poor gliding conditions have cut the number of birds over the runways by 95 per cent. The number of collisions has been reduced by 67 per cent. However, having been defeated before in the gooney war, the Navy stressed that the current report is a battle communique, not a report of final victory.

Ear on Space

Six hours a day the huge radio telescope at Green Bank, West Virginia, is pointed at the sky—in the hope of picking up signals from intelligent life on other worlds.

This is project Ozma, named after the storybook land of Oz, a faraway place populated by strange beings. At the outset of the project, the cosmic ear is being pointed at two relatively near neighboring suns, Tau Centi in the constellation of Cetus (the whale), and Epsilon Eridani in the constellation of Eridanus. Both are 11 light years (66 trillion miles) distant.

The astronomers assume that if some intelligent beings in other solar systems were trying to communicate with other planets, their signals would conform to some simple code or pattern. The most universal of such a series of code patterns might be the prime numbers, such as 1, 2, 3, 5, 7, 11, etc., which would appear in any counting system (*see Science World, April 20 issue, "The Puzzle of the Primes"*).

Even if life exists within Cetus, communication with the "people" on its planets might be difficult. Radio signals traveling at the speed of light would

New York Herald Tribune photo

One puncture from spine of deadly stonefish would cause death or serious injury in most human beings. Fish lies on bottom in shallow water and takes on colors of its surroundings—hence, the name "stonefish." Venom is deadlier than that of any snake.

take 11 years to get there. The "conversation" would drag.

In addition, making our own presence known could court disaster. The "people" in Cetus, if they exist, might have a technology a million years ahead of ours, and regard us as a lower form of life not worth their attention. On the other hand, they might think we are ahead of them. In either case, it would be best to keep quiet and listen.

An estimated five per cent of all the stars in our own Milky Way galaxy have planets capable of supporting life.

Fallout in Plants

Plants may absorb fewer radioactive isotopes from nuclear fallout than was previously thought.

In all plants examined, more of the absorbed material was concentrated in the leaves than in the stems, roots, fruits or seeds—the parts of plants most commonly eaten.

Scientists of the Laboratory of Biophysics and Nuclear Medicine at the University of California Medical Center, Los Angeles, made their report after studying radioactive isotopes picked up by plants grown in boxes and exposed on the Nevada test sites.

They found that strontium 90 was the most common fission product absorbed. Radioactive iodine, barium, cesium and ruthenium were also picked up by plants, in the order given. Only traces of the rarer radioactive elements —cerium, yttrium and promethium— were absorbed by growing plants.

The amount of fission products absorbed differed with the type of soil and the species of plant. Radishes absorb only a little less radioactivity than beans, which absorb most. After beans and radishes, carrots absorb most fission products followed by lettuce and barley.

Experiments indicated that if calcium is added to calcium deficient soils, the uptake of strontium 90 is slowed. Non-decayed organic material added in unusually large amounts also tended to slow isotope absorption by plants.

Technicolor Swans

If the whistling swan that just flew past was bright blue or red or yellow or green—don't take it too hard. You are all right.

The gaily colored swans are being used by ornithologists of the Fish and Wildlife Service to learn more about the migrating habits of these birds and the flyways they follow.

The usual procedure for studying migration is to trap and band the birds. But an angry swan with a four-foot wingspread presents a challenge to even the most hardy bird bander. So the scientists hit on the dyeing program. The trapped birds are sprayed with brilliant colors.

There are 77,000 whistlers in the U. S. More than half of them winter in the Chesapeake Bay area, and the rest winter along the Pacific coast. In summer, the swans nest in northern Canada from Alaska eastward to Baffin Island.

Mapping the migration routes and nesting areas will be made much easier by the colors, permitting the swans to be easily observed in flight and on the nest. The reaction of the swans to all this is not known.

News Particles

Drifting Bottles

Putting a message into a bottle and setting it adrift is not new. But scientists are casting into the sea bottles designed to sink to the ocean floor. These bottles, distributed along the east coast of the U. S., will drift along the sea floor with the bottom currents. When the bottles are found, their migration will give scientists a better knowledge of these currents.

Anyone finding a bottle can receive 50 cents by returning the card inside to the Woods Hole Oceanographic Institution, Woods Hole, Mass.

Stonefish

The most "horrible" fish in the world is the thirteen-spined poisonous stonefish. A specimen was recently received by the New York Aquarium. If you step on the stonefish, you will be stone dead within the hour. Each of the spines on its back is supplied by two sacks containing poison more deadly than that of the most venomous snakes. The stonefish gets its name from the fact that it assumes the color of its surroundings and looks very much like a stone. The stonefish was shipped from California in plastic bags, in exchange for a couple of sharks.

Book Decay

Libraries all over the country are faced with a serious problem. A survey made by the Virginia State Library shows that by 1980, over 40 per cent of the books published during the previous 50 years will be so brittle they will have to be removed from circulation. Cause of the paper's brittleness—the acid content of the wood pulp used in paper manufacture. Researchers are now working on a technique to stop acid-caused decay of books by dipping the paper in a solution that neutralizes the acids.

Tower of Pisa

You can win a small fortune and become an honorary citizen of the city of Pisa, Italy. How? Find some way to stop the Leaning Tower from leaning more each year. The tilt increases one millimeter a year.

today's scientists

Dr. Paul C. Aebersold

Mister Isotope

Atomic Energy Commission

Ex-track star Aebersold is now star "salesman."

ONE day in 1932, a husky young athlete in a Stanford track sweater trotted up to the physics building at the University of California at Berkeley. He strode into one of the laboratories, looked around for a minute, then approached a blond young man who was bending over a square metal box with rods and wires sticking out of it.

"Do you know where I can find Professor Ernest O. Lawrence?" asked the Stanford runner, whose name was Paul Aebersold. "I'm a physics student and I want to ask him some questions about his invention. I think he calls it a cyclotron."

"I'm Professor Lawrence," said the youthful scientist. "And if you want to see the cyclotron, this is the main part right here. I'm trying to plug up a leak in the vacuum chamber."

A few minutes later, Paul Aebersold found himself at work, helping to repair a leak in the 8-inch cyclotron—one of the earliest forerunners of the powerful "atom-smashers" which produce man-made radioactive atoms, called *radioisotopes.* He had expected to spend about ten minutes in the lab. He stayed at Berkeley for ten years—first as a graduate student, then as a teacher and research scientist. He was a member of the team of scientists that produced some of the first man-made radioisotopes. He was a pioneer in the medical uses of these isotopes.

During the 28 years since his first meeting with the inventor of the cyclotron, Dr. Aebersold has devoted most of his time to the study of man-made atoms and their uses. Now, as director of the Office of Isotopes Development of the U. S. Atomic Energy Commission, he is the commission's chief "salesman," encouraging the use of radioisotopes in hospitals, industries, agricultural experiment stations, research laboratories and schools. Every year he travels some 50,000 miles telling people about the peacetime uses of radioisotopes—from cancer research to food preservation, from insect killers to packaging gauges.

What are isotopes? They are simply atoms of an element which are like other atoms of the same element in everything but weight. The word *isotope* is made up of two Greek words—*iso* means "same"; *topos* means "place."

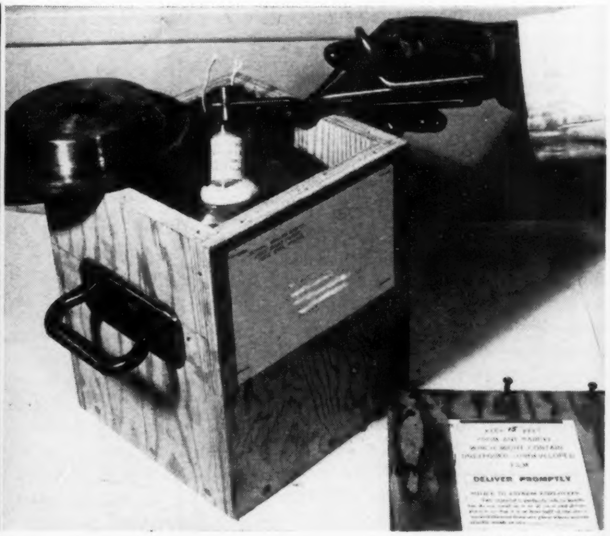
An element and all its isotopes occupy the same place in the periodic table—because all behave alike chemically, though they have different weights.

Some isotopes occur in nature. Others have to be made in the laboratory. Some are stable—others are radioactive. The radioactive ones give off radiation and they disintegrate into different kinds of atoms. Man-made radioactive carbon, for example, disintegrates eventually into stable nitrogen.

(Continued on page 28)

Atomic Energy Commission

Before being irradiated in nuclear reactor, the sample to be made radioactive is inserted in an aluminum capsule as shown. Isotopes have many uses in medicine, industry, and research.



National Film Board photo

Radioactive isotope of phosphorus made in Canadian nuclear reactor is being placed in heavy metal container for shipment to scientific researchers. Note the precautions taken.

tomorrow's scientists

PROJECT: Determining Mass by Acceleration

STUDENT: **FRED BROWN** SCHOOL: WHEATON HIGH SCHOOL, WHEATON, MARYLAND

WINNER, STUDENT ACHIEVEMENT AWARD, FUTURE SCIENTISTS OF AMERICA TEACHER: **GLENN E. WARNEKING**

[Once in a while, along comes someone who looks at a formula and says to himself, "If I rewrite this formula in some other way the results may be most interesting and challenging."

Take the expression that acceleration is proportional to the force applied and inversely proportional to the mass of the object being accelerated, a=F/m. There is nothing so unusual about it. But if the equation is solved for m, it suggests a method of weighing objects in space where ordinary balances will not work because of the absence of gravity.

Fred Brown looked at the acceleration relationship and saw that he could use it to solve a problem in electronic weighing that may well have important applications in the gravity-free reaches of outer space.]

FRED'S PROJECT

I am writing about two separate but related projects. The first project was theoretical and I could not do it without special equipment. However, it provided me with an idea for my second project. The object of both of these projects was to determine the mass of objects by some method other than a conventional beam or spring balance.

My first idea was a device such as that shown in the illustration below. A is a wooden support. C is a wooden arm with a disc, D, attached at one end. The arm is supported by a spring, B, and is free to move up and down.

This system would work as follows: Alternating current with a variable frequency generated by a variable oscillator, E, would be fed through amplifier F. Amplified voltage would be fed through electromagnet G, to move a metal disc, which would make C vibrate.

The vibrations would cause a voltage to be generated in the phonograph cartridge H, which would be amplified by I, and fed to meter M.

The arm, C, would have a natural resonant frequency of vibration determined by the weight on D. When the oscillator is adjusted to this frequency, the arm would vibrate more and cause a larger reading on the meter. By adjusting the frequency of the oscillator and watching the meter, it would be possible to tune the oscillator to the resonant frequency of the arm. If the oscillator control was calibrated in grams, the mass of an object could be determined by turning the oscillator control to the point where there is a maximum meter reading, then reading the gram calibrated scale of the control.

After I thought this out, I started experimenting with the parts of the system. I found that, to be accurate, the arm would have to have a very low frequency of vibration, about 2 cycles per second. Then my troubles began. First, I had to build an oscillator capable of a frequency range of ¼ to 20 cycles per second without any appreciable change in output voltage. Second, I would have to build two specially designed amplifiers capable of a very low frequency response. Third, I would have to build or acquire an oscilloscope to measure the voltage because a meter would pulsate too much at this low frequency to be read accurately. This was too much. I had to give up due to lack of equipment. However, I did not give up the entire idea. I reasoned out another way to make the weighing system work.

The new system uses the same vibrating arm and operates on the principle stated in Newton's Second Law—the acceleration (or deceleration) of an object is directly proportional to the force applied and inversely proportional to the mass of the object—a=F/m.

If the arm, C, equipped with a spring, is pulled to one side and released, the spring will exert a force on the arm and accelerate it toward its normal center position. The arm, because of its momentum, will continue past center. The force of the spring will oppose and finally stop the motion and the arm will then reverse direction, return to center and pass it in the opposite direction.

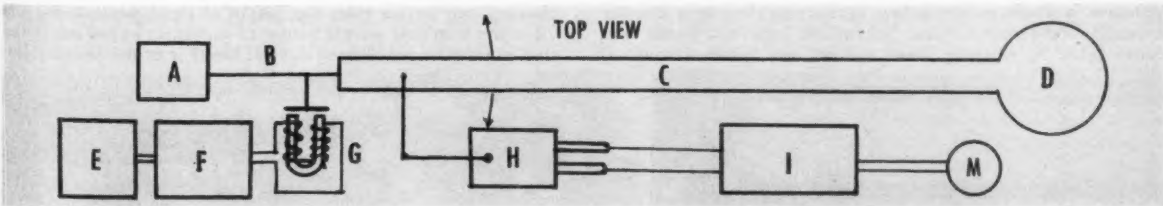
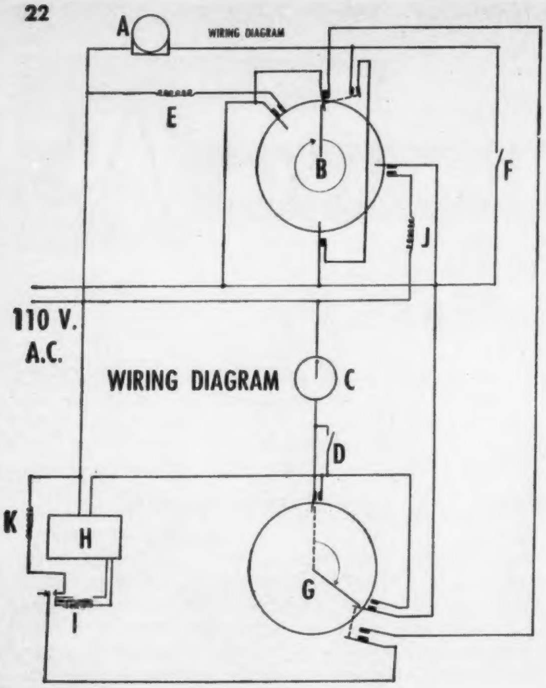
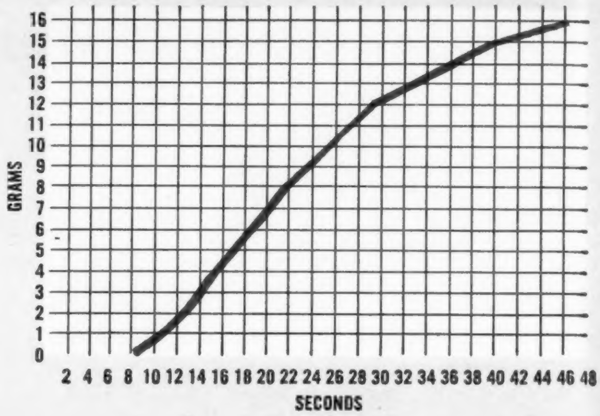


Diagram above is theoretical device Fred designed to measure mass independently of gravity. Details of theory and construction are given in Fred's report. In brief, theory was that vibrations of disc, D, would be picked up and measured by circuit involving phonograph cartridge, amplifier and meter. Technical difficulties caused design to be modified.



Wiring diagram: A, motor for synchronizer control, B; C, timer; D, push-button timer control; E, electromagnet; F, synchronizer control starter; G, step counter; H, phototube, power supply, amplifier; I, relay; J, step counter reset magnet; K, step-counter electromagnet. Balance counts 20 cycles, shuts off.



Graph of data obtained during test run shows that from 1 to 11 gm relation between mass and time correspond to theoretical expectations. After 11 gm, friction has an effect on accuracy.

The cycle will be repeated until friction or some other force stops the back and forth motion of the arm.

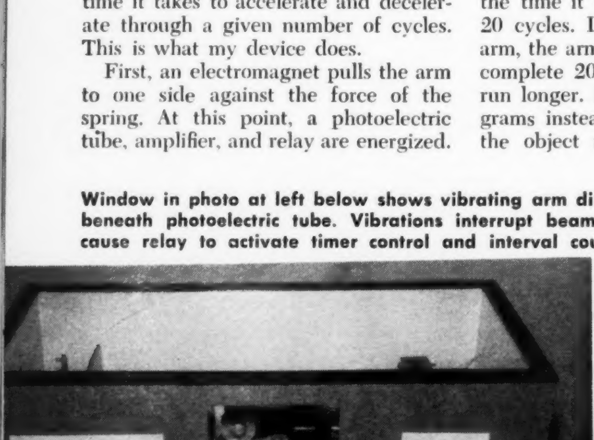
If a mass is placed on D and the arm is once more pulled to one side and released, the force of the spring will accelerate the arm and the added mass. However, because the total mass being accelerated is increased while the force is the same, the arm will accelerate more slowly. If the acceleration is decreased, the time it takes the arm to make one cycle will be increased in the same proportion. It is now apparent that an increase in mass will produce a proportional increase in the time it takes for the arm to complete one cycle. Because of this, it is possible to measure the mass of an object by measuring the time it takes to accelerate and decelerate through a given number of cycles. This is what my device does.

First, an electromagnet pulls the arm to one side against the force of the spring. At this point, a photoelectric tube, amplifier, and relay are energized. But the vibrating arm is placed so that as it moves back and forth it interrupts a beam of light to the phototube. This causes the relay to open and close. The electromagnet is then de-energized and the arm is released. The relay is connected to an electromagnetic step-counter which counts the pulses received from the relay. As the arm moves back and forth it interrupts the beam of light to the photoelectric tube and the step-counter counts the number of cycles it makes.

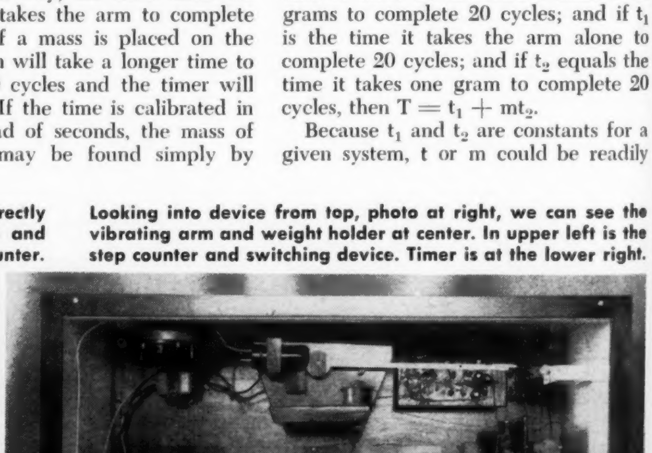
On the first pulse, the counter automatically starts a timer. The counter counts 19 cycles made by the arm and then on the 20th cycle it automatically turns off the timer and the other equipment. In this way, the timer measures the time it takes the arm to complete 20 cycles. If a mass is placed on the arm, the arm will take a longer time to complete 20 cycles and the timer will run longer. If the time is calibrated in grams instead of seconds, the mass of the object may be found simply by looking at the timer. The operation of this project is made much simpler by the use of a motor-driven control which automatically synchronizes and performs many of the steps necessary.

To convert the timer from seconds to grams theoretically may be done by the use of a simple formula, but in actual practice it takes more than the formula. In a theoretical situation each one-gram-mass added to the arm would add a certain number of seconds to the timer during 20 cycles. (In practice, this value is not constant because of the weight of the heavier mass on the arm.) There is also a certain number of seconds needed for the arm alone to complete 20 cycles. If T equals the time it takes the arm and a mass of m grams to complete 20 cycles; and if t_1 is the time it takes the arm alone to complete 20 cycles; and if t_2 equals the time it takes one gram to complete 20 cycles, then $T = t_1 + mt_2$.

Because t_1 and t_2 are constants for a given system, t or m could be readily



Window in photo at left below shows vibrating arm directly beneath photoelectric tube. Vibrations interrupt beam and cause relay to activate timer control and interval counter.



Looking into device from top, photo at right, we can see the vibrating arm and weight holder at center. In upper left is the step counter and switching device. Timer is at the lower right.

calculated when given the other. In my experiments the value of t_1 is 9.2 seconds, and the value of t_2 is approximately 1.65 seconds for masses between 0 and 11 grams. Because each gram adds a certain number of seconds during 20 cycles, a graph of mass and time should be linear. The graph shows the data obtained during a test run of my device. The graph is nearly linear from zero to 11 grams. For masses greater than 11 grams, the time gradually increases. This increase in time, which is not proportional to mass, is caused by the effects of increased friction on the functioning device.

There are two factors which greatly affect the accuracy of this device. The first is temperature. If the temperature of the device is increased, two things happen. First, the wooden arm lengthens, and second, the spring becomes less springy. Both have the effect of increasing the time by decreasing the force acting on the mass. The second factor which influences the accuracy is placement of the masses on the disk. Given constant temperature changes and proper placement of the masses, the accuracy of the device is plus or minus 0.1 gram from zero to 16 grams. A change in mass of as little as 0.5 gram can be detected.

This project may be of practical applications in space travel. In a rocket ship in outer space with no gravity acting, it would be impossible to measure the mass of an object by the use of pan balances or spring scales. The accuracy of the device I have developed would actually be improved by the removal of gravity.

PROJECT: The Effect of Test Atmospheres on Plants

STUDENT: **JAMES MURDOCK** SCHOOL: MADISON HIGH SCHOOL, MADISON, NEW JERSEY

WINNER: STUDENT ACHIEVEMENT AWARD, FUTURE SCIENTISTS OF AMERICA TEACHER: **EDWIN H. COOPER**

[Every biology and botany textbook will tell you that the higher seed-producing plants require free oxygen. Most people would accept the textbook as authoritative and let it go at that. But scientists are apt to be skeptical of authority and often ask questions that don't seem to make a lot of sense. For example, being told for years that plants require an atmosphere of oxygen and carbon dioxide, who but a scientist would ask whether plants can grow in atmospheres of other gases?

James Murdock asked this question. By careful planning, he put his question in such a way that the answer was unmistakable—one plant, the tiny duckweed, not only grows in an oxygen-free atmosphere—but thrives!

Now here is a puzzle. Did James Murdock make an error? Did he fail to control some important variable? Was the atmosphere really free of oxygen? And, if it was, are the textbooks in error?

Read his report carefully. What are your conclusions?]

JAMES' PROJECT

The purpose of my experiment was to find out what types of atmospheres are needed to support plant life.

The main problem of my experiment was to devise a suitable, inexpensive, easy-to-construct atmosphere chamber, one that would show the plant clearly for observations and would not require close attention over weekends and school vacations.

The next big problem was to find a suitable plant. The plant would have to be of a type that would not need close attention for watering and proper lighting. I wanted a small plant that would show changes without having to be removed from the chamber.

Then I had to find out how to prepare the test atmospheres and devise a method of filling the chamber. Special care had to be taken to make sure the atmosphere contained only the test gas.

The last problem of my experiment was to devise a seal that would not allow changes to take place in the atmosphere because of leakage.

After listing the problems I had to overcome, I decided to try to solve the most difficult one first—obtaining an atmosphere chamber to meet the test requirements.

My first idea was to construct a chamber by using plexiglas. Such a chamber would require special apparatus for emptying it of air, and a pressure device for filling it with the various atmospheres.

I drew up plans for the construction of such a chamber. But because of its expense it would have been impossible for me to construct the number needed to carry on my experiment successfully. I decided at the beginning of junior year to devise a better and more economic type of atmosphere chamber.

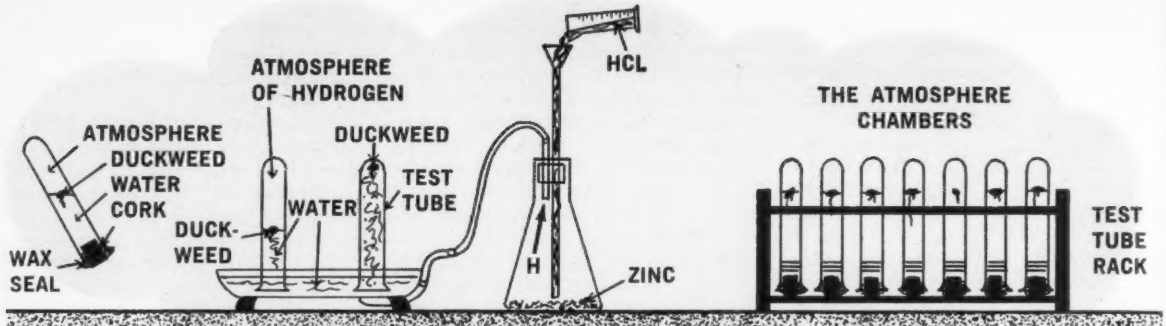
The method I finally used was one I devised shortly after having started gas experiments in chemistry. The class had an experiment involving the downward displacement of water for collecting hydrogen gas. One of my diagrams shows how I used this technique for obtaining a test atmosphere.

Then everything seemed to come at once. I got the idea of using test tubes as atmosphere chambers and using the downward displacement of water for filling them. The gas used for a test atmosphere was generated in a generator made from a flask and thistle tube. This method seemed to be foolproof both for removing all air in the test tube and replacing it completely with the desired atmosphere. I liked this idea, for it was quite versatile. I was able to make many such chambers, each independent of the other and requiring very little attention after they were sealed.

Duckweed in Inverted Test Tubes

I decided to use a small water plant which would depend only on the foods dissolved in the water. However, if additional nutrition appeared necessary, common fertilizer could be added to the tube and water. The name of this little plant is duckweed, of the order *Lemnaceae*. It floats on the surface of the water. Thus any changes in the physical features would show in several different ways. (This I found out after using the plant.) Duckweed is quite a rugged plant and does not require a lot of attention (light, food supply, temperature, etc.).

The actual method I used for combining the plant, chamber, and atmosphere is quite simple: The test tube is filled with water and inverted in a small pan. Next, one or two duckweed plants



Sketch shows methods and procedures used to set up chambers of pure gas as test atmospheres for plant culture. In center, hydrogen gas is prepared in generator. Test tube containing plant and water is inverted over jet and gas is collected by downward displacement. Tube is then corked and sealed with wax as in tube at left. Rack of specimens is easily observed.

are placed under water with a small spatula and guided into the submerged mouth of the test tube. The natural buoyancy of the duckweed plants carries them to the dome of the test tube when the inverted tube is filled with water. The plants remain in the dome of this airtight chamber until the test atmosphere is bubbled into the test tube. Then they go down with the water level as the test atmosphere replaces the water. If the test is to be run with added fertilizer, it can be introduced into the tube in the same manner.

After the desired amount of atmosphere is reached, the tube is moved away from the stream of gas bubbles and tightly corked while still submerged in the pan. This seal is completely adequate because the water separates the gas from the cork. However, to make doubly sure, the corked test tube is sealed with wax. The chambers with their plants and test atmospheres are independent of each other and require no further attention. The only other requirement is light.

A control utilizing ordinary air was established for each of the separate experiments.

In all, I used 16 different gases and made 55 different atmospheres by mixing them with air or themselves. In cases where it was impossible for me to make my own I used some bottled gas. The 16 different gases were: Acetylene (C_2H_2), Ammonia (NH_3), Argon (A), Carbon Dioxide (CO_2), Carbon Monoxide (CO), Chlorine (CL_2), Ethylene (C_2H_4), Helium (He), Hydrogen (H_2), Krypton (Kr), Methane (CH_4), Neon (Ne), Nitrogen (N_2), Nitrous Oxide (N_2O), Oxygen (O_2), Sulfur Dioxide (SO_2).

In addition to the duckweed, two African violets were also used. In some of the tests I used a commercial fertilizer with the plants. About half of the tests were run with distilled water. All water was boiled to eliminate oxygen.

Transcript from Log Book

Argon Experiment, Tube Chamber #13

November 5, 1958

One healthy duckweed plant is placed in an atmosphere of pure argon, without fertilizer. A control is started, also without fertilizer.

November 10, 1958

There is a big change here: the test plants are larger and more healthy than five days ago. The plants have multiplied from one to four. They appear greener in color than before. The control dropped its roots but looks O.K.

November 11, 1958

The test plants are larger and growing well. The control shows no change.

November 13, 1958

The test plants are larger yet and still growing well. They are starting to multiply again. There is a greenish-brown substance in this tube. The control is dividing a little.

November 20, 1958

The test plants are very mossy in texture and are just a little larger than before; I think that they have stopped growing. . . . They are much larger than when they were put in the tube 15 days ago. The control is still one plant . . . it did not divide.

December 3, 1958

The test plants seem healthy and appear to be growing well . . . still have mossy texture. This mossy substance was found in the water in a greenish-brown form. It is an algae, Chlamydomonas. It appeared in the tube with the argon atmosphere first, but later appeared in the control and overgrew the control. A small amount remained in the argon tube. The control has finally divided, but one of the plants is dead. The other plant looks healthy.

January 6, 1959

The test plants are still alive and growing well. The algae-invaded controls are all dead.

After observing the reactions of duckweed in different atmospheres, I found that many atmospheres would support plant life. In an argon gas atmosphere, the plants showed large changes in their physical features. The important implication here is the fact that an inert gas, argon (used mostly to replace oxygen when combustion is not desirable . . . as in light bulbs), apparently provides the duckweed plant with a better environment for growth than ordinary air.

Duckweed grew very large and multiplied at a rate which a professor at Drew University, who is very familiar with these plants, thought incredible. The fact that they even lived in such an atmosphere, in itself, is an unusual phenomenon. But the plants actually appeared to thrive in what was inert atmosphere.

Conclusions and Implications

In later experiments the water was boiled—distilled water which excluded all known possibilities of the presence of oxygen in the water. For every test run, there was a control to compare. In repetitions, plants in an argon atmosphere chamber surpassed the control in every way.

This could mean that there is another use for argon, not known before. The fact that the growth of Chlamydomonas algae was held down in the argon atmosphere, while it grew and killed the control, might imply that the argon atmosphere also inhibits the growth of some plants.

The fact that these plants survived in an atmosphere other than the one natural to our planet suggests it might be possible for life to exist on other planets and environments that we are not familiar with today.

With further research it might be possible to make an argon fertilizer or use this inert gas in some way to stimulate plant life.

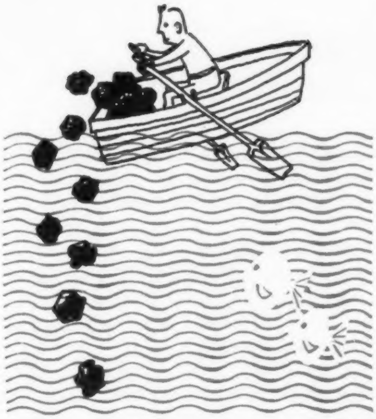
BRAIN TEASERS

Row, Row, Row Your Boat

While a man is rowing a boatload of rocks across a pond, an accident occurs. Most of the rocks fall overboard. The boat, now being lighter, floats higher in the water than it did before. But will the water level in the pond rise or fall because of the rocks that fell overboard?

David Emme
Hopkins South Jr. H. S.
Hopkins, Minn.

Answer: The water level will drop. In the boat, the rocks displace an amount of water equal to their weight. In the pond, they displace an amount of water equal to their volume. Since a given volume of rock weighs more than an equal volume of water, the rocks displace a greater volume of water when afloat than when sunk. Therefore, the sunken rocks will lower the level of the pond.



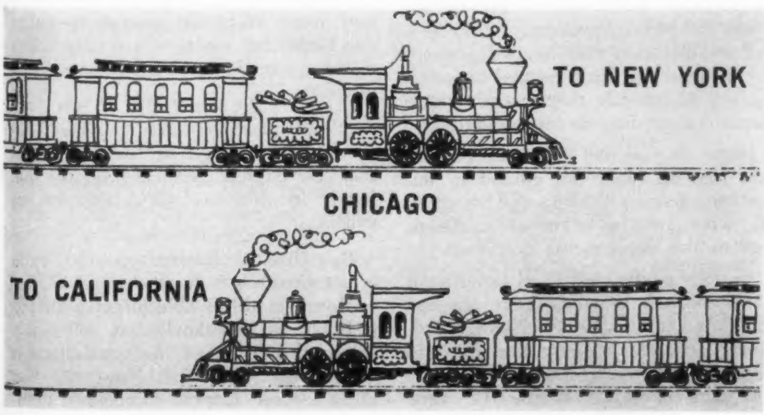
Lucky Friends

A man living in Chicago has two friends, one in New York and one in California. To visit his friend in California, he goes to the railroad station and takes a westbound train. To visit his friend in New York, he goes to the station and takes an eastbound train. The same number of trains leave for both east and west at regular intervals.

Since he likes both his friends equally well, when he feels like making a visit at any random moment, he goes to the station and simply takes the first train that pulls into the station. Yet for some reason he finds himself spending most of his time with his California friend; in fact, he finds himself in California nine times out of ten. Can you explain why the odds should be so heavily in favor of California?

Geoffrey Hingston
St. Mary's School
Williamstown, N. J.

Answer: The solution to this strange situation is simply a matter of train schedules. The train to California always arrives at Chicago just ahead of the train to New York. While both trains arrive at the Chicago station equally often, say at ten-hour intervals, the schedules may be such that the New York train always arrives one hour after the California train. If our passenger always arrives at the station at random moments, chances are nine out of ten that the first train pulling into the station will be bound for California. Although he arrives at the station at random times, the trains arrive at regular intervals which determine the odds in favor of a trip east or west.



Census Error

A census taker made a report on a certain community in which lived only young married couples and their children. In his report, the census taker stated that:

There were more parents than there were children
Every boy had a sister
There were more boys than girls
There were no childless couples

Although all these statements seem to make sense, they are not all consistent with each other. Can you show that the census taker made an error?

Leonard Olen
St. John Kanty Prep. School
Brooklyn, New York

Answer: Since there were no childless couples, and since every boy had a sister, every family must have at least one girl. Thus there must be at least as many girls as families. But since there are more boys than girls, the total number of children must be more than twice the number of families; that is, more than the total number of parents since there are just two parents for every family. This contradicts the first statement, which says that there were more parents than children.

Timetable

A railroad running between New York and Washington has the following schedule: A train leaves New York for Washington every hour on the hour, and a train leaves Washington every hour on the hour for New York. It takes four hours for the trip from New York to Washington, and four hours for the trip from Washington to New York.

Suppose you are on a train pulling out of the New York station right on the hour. Just as your train is pulling out, a train from Washington is arriving. Counting this arriving train, how many trains will you see en route from New York to Washington?

Ian D. McKay
Halifax, Nova Scotia

Answer: Since it takes four hours to make the trip from New York to Washington, you will pass the trains which left Washington during the four hours previous to your departure. These trains are already on the tracks when your train leaves. During your own four hour trip, four additional trains will leave Washington and will pass you, making a total of eight trains. In addition, as you are pulling into the Washington station four hours later, you will be just in time to see another train pulling out. This makes the correct answer nine trains.

Do You Think Like a Scientist?

Meeting the Test

By THEODORE BENJAMIN

WHEN you are presented with scientific data, can you draw the proper inferences, can you plan the proper experiments to verify your hypotheses, are you aware of the limitations of your conclusions?

The following selection deals with research on the migratory habits of birds. Read it as you would a mystery story. Don't look at the end to see "who done it." Stop reading at each question and answer it before proceeding. The answer to each question will usually be found in the sections that follow.

The navigational powers of birds have fascinated investigators for more than a century. A single example will show the remarkable nature of these powers. The North American golden plover migrates each fall from its breeding grounds in northern Canada to its winter home in the Hawaiian Islands. This bird cannot rest on the water; it must fly over thousands of miles of open ocean. If it wandered only slightly off course it would become lost and fall exhausted into the faceless Pacific Ocean. But it finds its way unerringly to Hawaii.

[What theories can you propose as to the method by which these birds are able to navigate so well?]

Attempting to explain the incredible navigational feats of birds, some scientists proposed that the birds were guided by the earth's magnetic field. Others suggested that the Coriolis force arising from the earth's rotation was the key to the navigation puzzle. Another theory stated that it was the sun's position that guided the birds, and yet another that they were guided by the star constellations at night. Others said that the birds relied on landmarks.

[Arrange the five theories suggested above in the order in which you would rank them as being the probable answers to the question: how do migratory birds find their way?]

The idea that they were guided by the sun was not taken seriously until the early 1950's, when experimenters began to turn up some interesting evidence. Two independent experimenters discovered that pigeons and wild birds were able to use the sun as a compass.

[Suppose that you wanted to find the direction of north during the daytime, using the sun's position as your reference. What additional information would you require?]

Experiments with warblers, noted for their long-distance migration, strongly indicate that the birds can use the sun as a compass and possess a "time sense" which allows them to take account of the sun's motion across the sky.

But warblers migrate mostly at night. This suggests that they can also take reference from the constellations or relative positions of the stars.

[Is this a reasonable assumption? How would you test this hypothesis?]

To explore the orientation question, the British ornithologist, E. G. F. Sauer, experimented with several species of warblers, each with a different migration route. The birds were placed in a cage with a glass opening at the top, uncovered at night so that they could see a part of the sky but nothing else. At the season of migration the birds would begin to flit about, and each would take up a position pointing in a particular direction, like the needle of a compass. When the cages were rotated, the birds stubbornly turned back to the preferred direction. In each case, the direction was exactly that of its migratory route. Cloudy nights confused the birds. Apparently, to keep a definite direction they needed a starry sky. In fact, the birds seemed to watch the sky so intently that meteors made them change direction momentarily.

[How do you feel about the conclusion that all birds are guided in migration *solely* by the sun and stars? So far, what are the principal shortcomings of the experiments described?]

A more rigidly controlled experiment was indicated. Warblers were hatched and raised in completely closed, soundproofed chambers where they lived in perpetual summer conditions for several years. At migration time, the caged birds were placed in a planetarium; that is, under a dome on which was projected an artificial replica of the natural starry sky. Flight positions taken by the warblers were those of wild birds of the same species.

The artificial sky dome enabled the experimenters to shift the stars and constellations. By changing the north-south height of the stars, they could change the apparent latitude, as if the birds were farther south or north than they actually were. This ruse, however, did not greatly disturb the birds. They took up the expected position even to the point of turning to face the proper direction when the migration route took a turn at a given latitude.

By shifting the artificial sky in an east-west direction the birds' apparent longitude could be changed. Since most migratory routes are in a north-south direction, an east-west shift generally put the birds well off the usual migratory route.

[What do you think happened?]

When the artificial sky was shifted to place birds which normally fly from Britain to Egypt in the relative position of northern Siberia, the birds looked excitedly at the unfamiliar sky for several minutes. Then, one by one, they headed directly for the usual starting point of their migration!

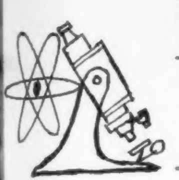
[How do you feel about the celestial orientation theory now? What further experiments are indicated?]

It would be interesting to determine how many stars are needed to guide the birds and whether a totally unfamiliar sky could serve as an orientation guide.

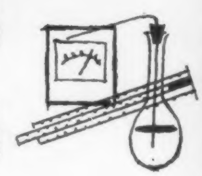
[What questions have now been developed as a result of the conclusion that celestial navigation is probably one factor in the migratory behavior of warblers?]

By what mechanism can the birds orient themselves by the stars?

How were birds able to make an adjustment to the slowly but constantly changing pattern of the constellations over many centuries? How did the birds become adapted to celestial navigation in the first place?



PROJECT POINTERS AND STUDY IDEAS



By **MURL SAILSBURY**
Evanston Township High School
Evanston, Ill.

Here are 41 more ideas for projects, research and discussion. Some of them have no definite answer. They are the springboards for fact-supported argument. And, who knows? Out of discussion may come a testable hypothesis. Among the project pointers are some that will keep you busy all summer—or a lifetime.

1. Lichens are interesting life forms. Are they a single plant? More than one species for each lichen? What are their life processes?

2. Brownian movements. All molecules are moving randomly. They collide and bounce. Methods for visually demonstrating Brownian movements.

3. Water holding capacities of various soils. Use standardized containers, procedures, etc.

4. Origins and phylogenetic relationships of common food plants. Corn? Wheat? Rice? Popcorn? Pumpkins? Celery? Watermelons? Others?

5. Microorganisms other than bacteria which fix atmospheric nitrogen. There are quite a number.

6. Common substances and their pH. Peaches. Sweet milk. Sour milk. Lemons. Saliva. Vinegar. Others.

7. Diagrams of atoms, some simple, some complex, showing their nuclear and electron structures. Protons. Neutrons. Electrons. Orbits—"shells." Relationships to such things as chemical activity. Magnetism? Luster? Transparency? Opaqueness? Others?

8. How has the age of the Earth been determined? So to speak—how much older has it become in the past human generation or so? 25 years? 10^6 years? 10^9 years? More?

9. Topology deals with surfaces. Look up**Moebius strips,** etc. Make some.

10. What are the differences between biosynthesis and chemosynthesis?

11. An experimental and display project dealing with soil conditioners.

12. Culturing compost organisms.

13. The pH of human blood is almost constant. It is maintained by buffers. References are fairly easily found.

14. How can ion exchange materials pick up one kind of ion under one condition, and release these ions for different ones under different chemical conditions?

15. Magnetic liquids and solutions. Do they exist?

16. Some magnetic materials can be suspended in liquids. Such a suspension can be caused to "jell" by electromagnetism. This induced change of viscosity suggests many applications. Clutches? Cores? Measuring devices? Flow control devices? Others?

17. Possible use of thermo- or chemosetting plastics in production of ferrite magnets without the need of firing.

18. Possible use of ferro and other permanent magnets, and a "floating" magnetic pan to produce a chemical "balance" or other weighing device.

19. How rapidly do particles diffuse in liquids? Gases? Solids? Can these rates be predicted mathematically?

20. A search for decay microorganisms which produce pleasant odors. Could they be cultured and used to inoculate garbage dumps, septic tanks, and the like?

21. Bacteria possess an electrostatic charge. Could ion exchange materials be used to remove bacteria from solutions?

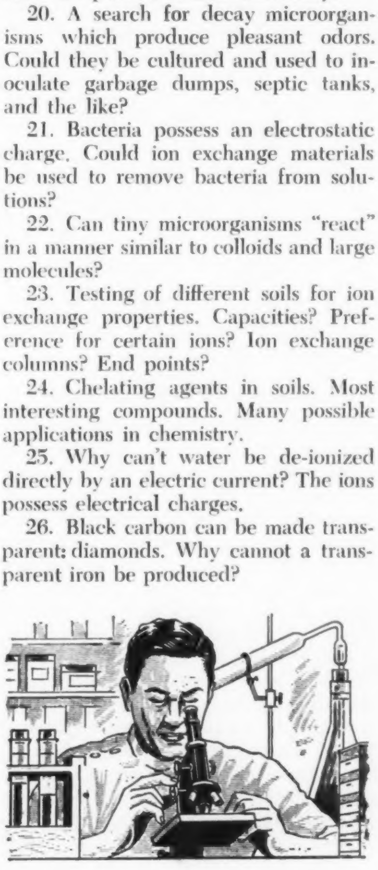
22. Can tiny microorganisms "react" in a manner similar to colloids and large molecules?

23. Testing of different soils for ion exchange properties. Capacities? Preference for certain ions? Ion exchange columns? End points?

24. Chelating agents in soils. Most interesting compounds. Many possible applications in chemistry.

25. Why can't water be de-ionized directly by an electric current? The ions possess electrical charges.

26. Black carbon can be made transparent: diamonds. Why cannot a transparent iron be produced?



27. Experimental comparisons of eddy currents in ferrite and metallic magnets. How manifested? Effects upon efficiency in specific applications.

28. The Curie point indicates that heat causes substances to lose their magnetic properties. Any evidence or reason to hypothesize a relationship between heat and production of magnetism? If so, applications? A thermagnister? Could they be used in autos (and other devices) to eliminate radiators and generators?

29. Is there a relationship between temperature and the amount of magnetism retained by substances? If so, could ferrites (and other minute magnets) be circulated in suspension and provide a means for accurate temperature and other measurements in specific applications? They could be magnetized to some standard prior to circulation.

30. Use of microwaves for precise measurements. Oscillators are not too difficult to build. Phasing? Applications?

31. Liquid oxygen is magnetic. Try to account for this in terms of electron spin.

32. Are the hairs of mammals alive?

33. Why does water expand when heated? Contract when cooled?

34. How can radiocarbon be used to date ancient plant and animal tissues? What effect have atom bomb tests had on this dating method?

35. How are radioisotopes transported? Trains? Planes? Trucks? Mails? How packaged?

36. Trace the path of the blood throughout the human body. How many trips would the same corpuscle make through the body in, say, an hour?

37. History of weighing devices. Models? Diagrams? Paper?

38. Could one lose weight by traveling from New Orleans to Denver?

39. Find some duckweeds. Do they produce seeds?

40. Hormones control and regulate many processes of animals such as growth, metabolism, and emergency responses. Prepare a display of the human endocrine gland system.

41. How are parts per million (ppm) solutions prepared? An interesting study and project could be that of the various methods for indicating the concentrations of chemical solutions—ppm, molar, normal, per cent, others.

Sci-fun

"Make a wish."

"All right. Now's your chance to show us how your rain making machine works."

Mister Isotope

(Continued from page 20)

Hydrogen isotopes are probably the easiest to understand. There are three kinds of hydrogen atoms. Scientists call them hydrogen 1, 2, and 3—or protium, deuterium and tritium. The most common hydrogen atoms found in nature are hydrogen 1, which has a weight of approximately one unit of atomic mass. Each protium atom contains one proton in its nucleus with an electron—which has relatively no weight—revolving around it. Deuterium, or hydrogen 2, is twice as heavy—but it also has one proton and one electron, giving it the same chemical behavior as protium. What gives it the extra weight? A *neutron*, added to the proton in the nucleus, weighs the same as the proton, but has no electrical charge and does not act chemically.

Tritium, hydrogen 3, is three times as heavy as hydrogen 1 because it has two neutrons added to the one proton in its nucleus. It is radioactive and disintegrates into a stable isotope of the element helium.

Both hydrogen 1 and 2 are stable and are found in nature. Hydrogen 3 was made in a cyclotron before anybody knew that it existed in a natural state. A few years ago, traces of natural tritium were discovered.

With a few exceptions, most natural isotopes are stable. They don't disintegrate or change with time. Most radioactive ones are made artificially. Some, such as the heavy elements radium and radon, occur naturally. Best known is uranium—which led to the design and operation of the nuclear reactor. The cyclotron can make more *kinds* of isotopes than a reactor, but a reactor can produce, at much smaller cost, *larger quantities* of most of the isotopes that are useful.

Began with Crystal Radio

These isotopes are the full-time concern of Dr. Aebersold. His career in nuclear physics began in 1932, the day he called on Professor Lawrence, but he started thinking about science much earlier. Looking back, Dr. Aebersold remembers an early spark of enthusiasm kindled when he was about ten. "I guess it was science fiction," he said, "that first got me interested in physics. I used to like H. G. Wells and Jules Verne. Then I started reading any science magazines I could find."

When he was 12, young Paul came across an article that told him how to build a crystal radio set. He could hardly wait to assemble all the parts. "I used my own money," he recalls, "so it took a good deal of saving and planning. I'll never forget the thrill of first hearing voices and music on my radio—and thinking of this miraculous transmission through space. I relived this thrill last year when my 16-year-old son, Paul, built his own radio—but his was built with transistors."

By the time he reached college, Paul Aebersold's mind was made up. He was going to be a physicist. As a physics student at Stanford, he maintained an A average, made Phi Beta Kappa in his junior year, and received his B.A. degree, cum laude, in 1932. But it was not his academic record that led him to Berkeley, where he joined the pioneer team of atom smashers. Paul Aebersold was a track star, too.

Mission: To Educate Public

That year, 1932, the Olympic tryouts were being held at Berkeley. Young Aebersold went up from Stanford for the tryouts and decided to take some summer courses at the university. That's how he happened to call on Professor Ernest Lawrence.

At Berkeley Dr. Aebersold helped to build the 27-inch, 60-inch, and 184-inch cyclotrons, producing many of the first man-made isotopes. Convinced that isotopes could be valuable tools in medicine, he aided in the first experiments to determine the effects of nuclear radiation on animals. Then he helped to develop techniques for treating human beings with man-made radioactive materials. He was the first to calculate proper dosages. Dr. Aebersold was responsible for experiments that led to the first program of laboratory safety for protecting scientists from radioactivity.

He is still concerned with safer methods of handling radioactive materials. But he feels that his main mission is to educate the public about what isotopes can do. Every week he makes at least two or three talks to such varied groups as manufacturers, doctors, advertising

Answers to Crossword Puzzle

(See page 30)

		B	I		A	S	H		B	F		
D	E	L	T	A		E		G	R	I	E	F
O	R	O	S		F	A	N		R	O	S	A
M		C			E		E			R		U
E	S	K	E	R	S		V	A	N	D	A	L
D	P		M	I	S		E	R	A		B	T
	A	R	I	D				E	T	N	A	
C	R	A	T	E	R		I	T	A	S	C	A
R	K		S	R	O		D	E	L		A	T
U		D			U		E			D		O
S	P	I	T		T	V	A		S	I	L	L
T	A	K	E	N		A		C	O	R	A	L
		E	N		N	N	E		B	T		

people, farmers, university professors, and nuclear physicists.

What *can* man-made radioisotopes do that nothing else can? Enough books and pamphlets have been written on the subject to fill a library. The list of Dr. Aebersold's own written works on isotopes fills five closely typewritten pages. Out of the thousands of uses for isotopes that have been described, here is one example of a medical use, in Dr. Aebersold's words:

"Let us assume that we want to find out how rapidly sodium travels through the body and at what rate it is taken into various body fluids and tissues. All we have to do is to take some table salt and irradiate it in the reactor at Oak Ridge. This gives us radioactive sodium. We can give some of this radiosodium to a person by mouth or by vein and then follow its path through the body with a geiger counter or some other radiation instrument.

"The gamma rays from radiosodium are so penetrating that we can detect them just by holding a counter over various areas of the body. This simple procedure allows us to see when blood carrying the radioactive sodium reaches a certain part of the body. In fact, this technique is used for determining the adequacy of blood circulation to . . . the arms and legs."

Avenue to New Knowledge

Using experiments such as the one described by Dr. Aebersold, doctors have learned that, in about 15 seconds, a dose of radiosodium will travel from one arm through the heart, through the lungs and into the other arm. Sixty seconds later, the sodium will be diffused into the tissues and will be excreted from the sweat glands on the opposite arm.

Radioisotopes have become a valuable product. The first shipment of man-made atoms for industrial use was made in 1946, when Dr. Aebersold was at Oak Ridge as director of the commission's Isotopes Division. Since then, 135,000 shipments have been made—valued at $19,000,000 ($1.9 x 10^7$).

Nineteen million dollars sounds like a lot of money, but if industry and medicine had done the same jobs with natural radioisotopes, the cost would have been many times greater. A million grams of radium, needed to produce this same amount of radioactivity, would cost $20,000,000,000 ($2 x 10^{10}$).

"Some isotopes, such as U-235, are a valuable source of power," Dr. Aebersold said at a recent press conference. "But isotopes in general are far more valuable through their power to gain new knowledge."

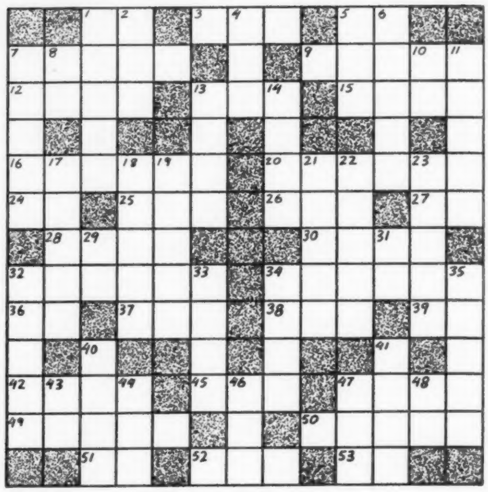
—Barbara Land

Down to Earth

By Helen Hibbard, Addison (N. Y.) Central School

★ Starred words refer to geology

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. **Answers to this puzzle are on page 28.**



ACROSS

° 1. Lustrous reddish-white metal found native in veins (*symbol*).
° 3. Fine bits of lava.
5. Inventor of lightning rod (*initials*).
° 6. Triangular alluvial deposit at the mouth of a river.
9. Sorrow.
12. Greek for mountain.
°13. An alluvial ______ is a slope of deposits at a mountain base.
°15. Monte _____ is in the Pennine Alps.
°16. Sand or gravel ridges deposited by subglacial streams.
20. One who mars something beautiful.
24. Displaced person (*abbr.*).
25. Prefix meaning wrong or badly.
°26. Period of geological time.
27. Bachelor of Theology (*abbr.*).
28. Dry.
°30. Volcanic mountain in eastern Sicily.
°32. Cavity at the mouth of a volcano.
°34. Source of the Mississippi River, Lake ______.
36. German bacteriologist and physician (*initials*).
37. Standing room only (*abbr.*).
38. Delaware (*abbr.*).
39. Chemical symbol for Astatine.
°42. Narrow sandbank extending from shore.
°45. Federal dam project for flood control in our Southeast (*abbr.*).
°47. Igneous rock that hardened between sedimentary layers.
49. Past participle of take.
°50. Reef made of skeletons.
51. Prefix meaning in or into.
52. North-northeast (*abbr.*).
53. Baronet (*abbr.*).

DOWN

° 1. ______ mountains are formed by the rising and tilting of Earth's crust.
2. Contraction for *it is*.
° 4. Salt water body.
5. Boston Railroad (*abbr.*).
° 6. Narrow inlet of the sea between high banks or rocks, as in Norway.
° 7. Natural formation resembling the cupola of a building.
8. Chemical symbol for Erbium.
10. Latin word for *you are*.
°11. A break in rock strata.
13. Wide horizontal band across the middle of an escutcheon.
°14. Granular icy material formed from compressed snow, the beginning of a glacier.
17. This is thrown off by a fire.
°18. A geyser ______ water.
19. One who rides.
°21. Sharp divide between two glacial basins.
22. Pertaining to one's birth.
23. Philippine plant that produces hemp.
29. Radioactive metallic element (*symbol*).
31. New Style (*abbr.*).
°32. Exterior portion of the Earth.
33. To poke, search, or rummage.
34. A thought.
°35. Ring-shaped island of coral.
°40. An intrusion of magma into a crack of bedrock.
°41. Soil or earth.
42. Short ton (*abbr.*).
43. Father (*colloq.*).
44. Roman numeral *X* stands for this.
46. Vehicle for moving furniture.
47. Weep.
48. Louisiana (*abbr.*).

Foolish Seedlings

(Continued from page 11)

Similarly, treat four other plants with 10 cc of a solution containing 10 parts per million. The remaining four plants are the controls, and should be treated with 10 cc of ordinary water applied in exactly the same way. Do this every two days. The solutions should be prepared fresh for each treatment, since gibberellic acid loses its effectiveness in solution after a few hours.

It is obvious that several possible variables in this project require rather careful control, if you want to be sure that the results can be attributed to the gibberellins. For example, the seed peas you start with should all come from the same packet. And what about the water used for the dilutions and controls? Distilled water would be best of all. An easy way to get it in quantities is from the frost and ice that collects on the inside of the refrigerator. But if you can't get distilled water, make sure that the water for dilution is always drawn from the same tap. In fact, it would be best to draw several liters at one time and use it for all experiments.

To eliminate or hold constant the effects of light and temperature, the plants should be kept in a dark room and illuminated for 11 hours each day with 40 watts of fluorescent lighting. This may be a little too much to ask your teacher or parents to put up with. If it is, you can rotate the plants on a window sill and make sure that experimentals and controls each get the same amount of light—as nearly as possible.

Results on the Record

Both experimentals and controls should be watered with an atomizer, but use separate atomizers for each group. The amount of fluid should be the same for both groups. Neither group should have any more water than that supplied by the test spray.

Record the height of each plant daily. The zero point will be the height on the day the experiment starts. After you have completed the experiment, it would make an interesting additional datum to record the weights of the individual plants—both experimentals and controls. They may be dried before weighing by stripping them of dirt and placing in an oven set at 150 degrees F. for several hours.

After reading the list of do's and don'ts, the whole thing may strike you as a lot of work. It is. But in carrying out the steps of this experiment you will be practicing good experimental technique. Keep in mind all the things a scientist must watch and control if he is to have confidence in his results. You will be that much farther along the road to the point where you can undertake an individual project of your own. There are very few things worthwhile that do not require self discipline and practice. And you may open the door to a summer of fun and discovery.

Gibberellic acid may be obtained from the General Biological Supply House, 8200 South Hoyne Ave., Chicago 20, Ill.; also from Charles Pfizer & Co., 230 Brighton Rd., Clifton, N. J.; and Merck and Co., 126 East Lincoln Ave., Rahway, New Jersey.

In the Next Issue

***Death of a Star*—What are the forces within a star that are believed to cause it to explode and die?**

***How Life Began*—Theories on the origin of life on Planet Earth.**

***Radioactive Wastes*—New theories on the disposal and dispersal of "hot garbage" from nuclear reactors.**

Science Achievement Awards

This year approximately 39,000 sets of student entry materials were requested for the 1960 program of Science Achievement Awards for Students (SAAS) of the Future Scientists of America. A response was received from 2,650 teachers (27 per cent more than last year), who received 26 per cent more materials than in last year's distribution. Approximately 6,400 student project reports were judged in the eleven regional divisions. This number represents a 25 per cent increase over completed projects submitted last year. NSTA, along with its sponsor, the American Society for Metals, is highly gratified at this demonstration of interest and enthusiasm.

Unfortunately, and this is repeated to alert everybody to the rules for future programs, not all students who completed their project reports could be included in the final judging of entries.

Some projects were late.

More than one hundred were mailed after the closing date of March 15, and therefore reached their destination after the judging had been completed. Secondly, about an equal number were mailed to NSTA headquarters instead of to the appropriate regional chairman, as directed in the instructions. Although these projects were immediately forwarded, most of them were too late to qualify.

Teachers are urged to make an effort in future programs to follow carefully all pertinent instructions on mailing, deadline date, and other regulations. Otherwise, students may be penalized or discouraged for reasons not of their own making.

Plans are now being made for the 1961 SAAS competition, and there is every indication that this worthwhile endeavor will continue to be sponsored by the American Society for Metals. Since the SAAS program stresses entries which are *reports* of investigative or research-type projects, and not displays, there is no reason to wait to submit the report until after a science fair or other similar activity.

As in other years, the names of all winners of awards and honorable mention in SAAS 1960, will be published in a special brochure which will be available about July 1. Single copies will be sent free on request. Since the listing will contain titles of award-winning projects, this brochure will be an excellent source of project suggestions.

NSTA Elections—1960

A new record for membership participation in a National Science Teacher Association election was set when more than 4,000 members cast their ballots to share in selecting the new officers and directors for the period of service commencing June 1, 1960.

We extend congratulations to those whom the voting members have called to further duties. The officers chosen this year are:

President-Elect—Dr. J. Darrell Barnard, New York University, New York City (1960-61; to be President in 1961-62).

Secretary—Mrs. Mildred T. Ballou, Station KDPS-TV, Des Moines, Iowa, Public Schools (1960-62).

Region II *Director*—Dr. Hugh Allen, Jr., Montclair State College, Upper Montclair, New Jersey (1960-62).

Region IV *Director*—Mr. Robert D. Binger, State Department of Education, Tallahassee, Florida (1960-62).

Region VI *Director*—Dr. Milton O. Pella, University of Wisconsin, Madison, Wisconsin (1960-62).

Region VIII—*Director*—Dr. Donald W. Stotler, Portland, Oregon, Public Schools (1960-62).

New Materials Catalogue

A new catalogue—an all-in-one source book of science teaching aids and supplementary materials—is now available at no cost to school personnel. The 36-page source book, prepared by the Science Materials Center, covers many of the areas in science and mathematics. Features:

1. Description of materials suitable for project funds under Title III of the National Defense Education Act. Plus practical suggestions for using the materials in the classroom.
2. Supplementary reading list for elementary and secondary level students covering more than 300 volumes, grouped by subject matter.
3. A 10-point check list for evaluating materials and equipment.

Comprehensive subject sections of the Science Materials Center source book include: astronomy, atomic energy, biology, chemistry, computers, electricity and pre-electricity physics, engineering and mechanics, light wave physics, magnifiers and microscopes, mathematics, measuring instruments.

The catalogue may be obtained from the Science Materials Center at 59 Fourth Avenue, New York 3, New York.

Conservation Accents Youth

The sixth annual conference of the Conservation Education Association gets under way August 15, 1960, at the State University Teachers College in Oneonta, New York. In keeping with the spirit of the White House Conference on Children and Youth, the four-day session moves into a new area of discussion, "Conservation Education Programs for Youth Groups." The conference program is being developed by the Girl Scouts, Campfire Girls, Boy Scouts, 4-H, Nature Centers for Young America, and the association.

The theme for 1960 will be thrown open to the youth organizations, teaching profession, conservationists, and representatives from industry, and public and private conservation agencies. Analyses of ideas and suggestions will be followed by formulations of policies and recommendations based on the premise that knowledge and practice of conservation is a wholesome, enjoyable, far-reaching, and essential activity for the youth of America.

One of the association's principal objectives is to provide leadership in forming conservation education policies. Past conferences have sought to upgrade teacher training in conservation, develop state-level coordination in conservation education, establish effective conservation instruction and activities in local school systems, and spread the idea and awareness of conservation to the general public. The outcome of the 1960 conference will mark a significant step forward in conservation activities among youth groups.

The Conservation Education Association, organized in 1953, is the outgrowth of a national educational committee formed by the Izaak Walton League of America in 1945. Its members represent most segments of our population and are united in the belief that the widest extension of sound education with respect to resource use is a goal worthy of the association's and the nation's greatest efforts.

Atomic Energy Lab Guide

Joe W. Tyson, of the Wm. B. Travis High School in Austin, Texas, has prepared a useful and immensely practical lab guide, *Atomic Radiation in the High School Science Class*. Although the experiments described are heavily biological in emphasis, they are not entirely so, and teachers of chemistry and physics will find the lab guide useful.

Many of the activities designed as student exercises in senior high could well be used as demonstrations in ninth grade general science classes. Complete and detailed instructions are given for more than 50 experiments and projects. Any teacher familiar with the rudiments of counter techniques, and monitoring and handling radioactive isotopes, should have no trouble in directing students to a satisfactory and safe outcome in the lab exercises.

In addition to the activities, the guide contains a bushel of useful information including bibliographies and sources of supply for both equipment and isotopes. The only oversight is Mr. Tyson's failure to include a chapter on the operation of the various types of radiation counters. This would have helped immensely. However, information on instrument calibration and background determination is widely available, and its lack is not a serious defect.

The book can be purchased from Oldfriends Books, 4923 Strauss Drive, Austin 3, Texas, for $1.65. Rarely is so much available for so little.

Record-Breaking Science Fairs

National Science Fair-International headquarters at Science Service, Washington, D. C., reports that science fairs are breaking all records this year, both in the number of students participating and in the quality of the projects exhibited.

To cite just two example, some 20,000 projects were exhibited in the Baltimore area of Maryland, while 30,000 were shown in the Kansas City, Mo., area. The culmination of 58 run-off fairs which exhibited 4,654 projects, the Greater Kansas City Science Fair judged 1,963 projects. In addition to awards made by the Fair itself, 32 special awards were presented.

When the National Science Fair opens in Indianapolis on May 11, some of modern science's most current advances and problems will be represented in the work of student scientists. Studies of space medicine, telemetry systems, computers, smog, tumor regression, bacterial mutations, a new silicon compound, anti-bacterial vapors, the juvenile hormone, and hundreds of other challenging subjects will be exhibited and demonstrated.

About 370 sophomore, junior, and senior high school students will be coming to the Fair as finalists, with approximately one third of them girls. More than 150 scientists will form 15 committees to judge the finalists' projects for some 150 awards.

Useful Solutions and Culture Media

This is the time of year for field trips. You may wish to have this year's biology students collect and leave a legacy of study materials for next year's. Plant materials collected on field trips may be preserved for student laboratory and teacher demonstration if kept in preservative solutions.

Many formulas are available and each has its advocates. A thoroughly satisfactory, all-purpose preservative for plant materials is F.A.A. (formalin—acetic acid—alcohol). Two formulas for its preparation are given:

Method A

50 per cent ethyl alcohol	90 cc
formalin (commercial)	5 cc
glacial acetic acid	5 cc

Method B

50 per cent ethyl alcohol	85 cc
formalin (commercial)	10 cc
glacial acetic acid	5 cc

F.A.A. serves as both fixative and preservative. Plant specimens may be stored in it for years. Green color may be preserved by first fixing specimens in F.A.A. solution that is saturated with copper sulfate. After the color is fixed (10-12 days) transfer to clear F.A.A.

Evergreen twigs and the immature male and female cones of conifers often become brittle, losing needles and scales. They can be treated before drying and pressing so that needles and scales will not shatter. The secret is to treat them for about 10 days to two weeks in the solution given below. Then remove them, dry, press, and mount.

Preservative Solution for Evergreen Specimens

glycerin	100 cc
50 per cent ethyl alcohol	100 cc
formalin (commercial)	5 cc
glacial acetic acid	5 cc
copper sulfate	1 large crystal (thumbnail size)

Poisoning Herbarium Specimens

Given half a chance—or any chance at all—insects thrive on herbarium specimens just as they do in nature. Protect the hours of work that go into preparing handsomely mounted specimens which can be as decorative as they are instructive.

A good method is to prepare a solution of 70 per cent alcohol saturated with bichloride of mercury (POISON). The specimens may be dipped—but it is better (and less messy) to paint it on with a fine camel's hair brush. The alcohol will evaporate and leave behind a coating of mercuric chloride that is sure death to all insect predators.

Culture Medium for Slime Molds

Materials:

2 gm powdered quick cooking oatmeal

8 gm Difco nutrient agar

400 ml cold distilled water

Procedure:

Pour powdered ingredients into the water in a liter flask. Bring to boil in water bath. Autoclave and store in refrigerator. To pour plates, melt over water bath and pour 15-20 cc in each petri dish, rotate.

After agar has set, place dried mold material (*see Science World, Feb. 17, 1960*) on agar and incubate at room temperature.

Knops Solution

Knops is a useful nutrient solution adaptable to a variety of cultures. It is frequently used for hydroponics and culturing fern prothalia and moss protonema. Two methods of preparation are given. However, almost every user of Knops or similar nutrient solutions sooner or later devises his own modification.

Method 1

KNO_3	0.5 gm
$MgSO_4 \cdot 7H_2O$	0.5 gm
$Ca(NO_3)_2 \cdot 4H_2O$	1.5 gm
KH_2PO_4	0.5 gm
$FePO_4$	trace
Distilled Water	1,000 cc

Method 2

KNO_3	0.2 gm
$MgSO_4 \cdot 7H_2O$	0.2 gm
$Ca(NO_3)_2 \cdot 4H_2O$	0.8 gm
KH_2PO_4	0.2 gm
$FePO_4$	trace
Distilled Water	1,000 cc

Use Knops solution diluted to ½ with water for fern prothalia grown by the inverted flowerpot method. To grow protonema, simply float spores on the surface of a jar or flask containing Knops.

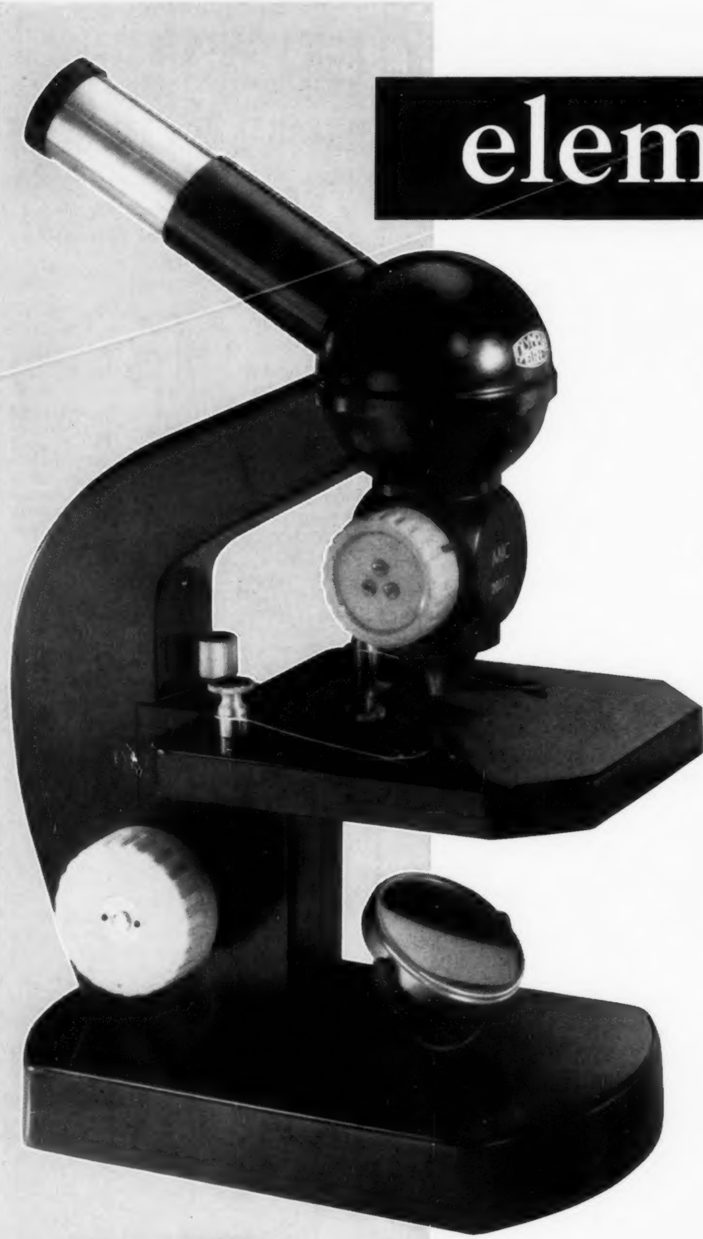
A very useful agar for sterile cultures of prothalia, protonema and seedlings of many plants can be made by diluting 100 cc of Knops to 400 cc and adding 8 grams of plain granulated agar. Autoclave and store until needed.

Seeds and spores should be sterilized by soaking in commercial bleaching solution before sowing them in sterile media.

Knops solution may also be used quite successfully as a nutrient medium for hydroponics or rooting cuttings.

For best results, don't dilute.

elementary!



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